GA502 – Level Design II – Session 04

UE4 Materials

- Assets applied to meshes to control the visual properties.
- A material is used to calculate how light interacts with a surface.

Material Editor

- Visual HLSL (High Level Shader Language) scripting.
- Similar functionality to the blueprint graph editor.
- Live Mode:
  - Live Nodes: only nodes are updated
  - Live Update: shader is recompiled each time (can be time consuming)

Material Expression Network

- Material Expressions are snippets of HLSL that are combined to form a network to create complex surface shaders.
- Material Expression outputs are fed into a Material node which combines them to into a renderable Material.
- Material Expression reference:

https://docs.unrealengine.com/latest/INT/Engine/Rendering/Materials/ExpressionReference/index.html

- Colors:
  - RGBA
  - Floating point (0.0 – 1.0)
  - Overdrive
    - Emissive >1.0 will increase brigtness.
- Textures:
  - Images that provide pixel based data.
  - Materials may use many textures as components.
  - Texture import:
    - Content Browser > Import > Select texture file
    - Supported formats:
      - .bmp
      - .float
      - .pcx
      - .png
      - .psd
      - .tga
      - .jpg
      - .exr
      - .dds (cubemap)
      - .hdr (cubemap)

- Texture Sample Node

Properties

https://docs.unrealengine.com/latest/INT/Engine/Rendering/Materials/MaterialProperties/index.html

- Define how Materials behave.
- Select Main Material Node in Material Editor.
- Physical Material:
  - Physical Material asset associated with the material.
  - Definition of its physical properties; Friction, bounce etc.
  - Has no visual effect on the material.
- Material:
  - Material Domain:
    - How the material will be used.
  - Blend Mode:
    - How the material will blend over things in the background.
    - BLEND_Opaque
      - Will occlude background
      - Compatible with dynamic lighting
    - BLEND_Masked
      - Will be fully opaque if opacity is greater than the OpacityMaskClipValue, otherwise it will be fully transparent.
      - Compatible with dynamic lighting.
    - BLEND_Translucent
      - Variable Opacity
      - Not compatible with dynamic lighting.
    - BLEND_Additive
      - Adds to background.
      - Not compatible with dynamic lighting.
    - BLEND_Modulate
      - Multiplicative to background.
      - Not compatible with dynamic lighting or fog.
  - Shading Model
    - Determines how inputs are combined to make final surface.
      - Default Lit
        - Default model.
      - Unlit
        - No response to light.
        - Emissive and opacity only.
      - Subsurface
        - Subsurface scattering materials.
        - Ice, wax, etc.
        - Activates Subsurface Color input.
      - Preintegrated Skin
        - Material for humas skin.
        - Activates Subsurface Color input.

        - Clear Coat
            - Translucent coating.
            - Car paint, lacquer, etc.
            - Activates Clear Coat and Clear Coat Roughness inputs.
        - Subsurface Profile
            - Advanced subsurface scattering shader.
            - Skin, ice, wax, etc.
    - Opacity Clip Mask Value
        - Sets threshold for opacity clip in masked blend mode.
    - Two Sided
        - Calculates lighting for both mesh faces.
    - Tangent Space Normal
        - Calculate normals from object surface rather than world space.
    - Use Material Attributes
        - Condenses Main Material Node to one input.
        - Good for layered materials.
    - Num Customized Uvs
        - Number of UV inputs to display.
        - Used for interacting with the vertex shader.
    - Generate Spherical Particle Normals
        - Surface normals remain spherical as you rotate the camera.
        - Useful for volumetric particle systems.
    - Emissive (Dynamic Area Light)
        - Materials emissive color is injected into the Light Propagation Volume.
    - Wire Frame
        - Enables a wire frame view of the applied mesh.
- Translucency
    - Defines translucency behavior.
- Translucency Self Shadowing
    - Provides a way to get volumetrically lit translucent objects. Smoke, steam, etc.
    - Broken into Self Shadow Density and Second Self Shadow Density to allow for variation in throughout the self shadow.
- Usage
    - Used to control the types of objects on which the material can be used
    - Allows the engine to compile special versions of the material for each application
    - Only valid for Surface Material Domain
- Mobile
    - Settings for mobile optimization.
- Tessellation
    - Runtime mesh tessellation settings.
    - Allows you to add more physical detail to meshes at runtime at the cost of performance.
- Post Process Material
    - Properties for Post Process Materials.
- Lightmass
    - Effect of transluce on static lighting.

- Material Interface
  - Allows you to set a custom mesh in the preview pane.
- Thumbnail
  - Properties of the thumbnail preview.

Inputs

https://docs.unrealengine.com/latest/INT/Engine/Rendering/Materials/MaterialInputs/index.html

- Feed values into the material to define the physical surface.
- Some inputs are automatically disabled based on:
  - Material Domain
  - Shading Model
  - Blend Mode
- Base Color
  - Defines overall color.
  - Vector3 (RGB)
- Metallic
  - How metal like the surface is.
  - Non-metals = 0.0 (black)
  - Metals = 1.0 (white)
- Specular
  - scales the specularity of non-metallic surfaces.
  - no effect on metals
  - No Specular = 0.0 (black)
  - High Specular = 1.0 (white)
- Roughness
  - Controls how rough a material appears.
  - Rough material will scatter more light.
  - Smooth (mirror) = 0.0 (black)
  - Rough (matte) = 1.0 (white)
- Emissive Color
  - Controls emissive areas and intensity.
  - Vector3 (RGB)
  - No Emission = 0.0 (black)
  - Full Emission = 1.0 (white)
  - Can be overdriven if HDR lighting is supported.
- Opacity
  - Translucent Blend Mode.
  - Transparent = 0.0 (black)
  - Opaque = 1.0 (white)
- Opacity mask
  - Masked Blend Mode.
  - Hard cutoff at clip value.
  - Transparent < OpacityMaskClipValue
  - Opaque > OpacityMaskClipValue
- Normal

        - Takes a normal map.
        - perturbates the normal of the pixel.
    - World position offset
        - Allows mesh vertices to be manipulated in world space by the material.
        - Useful for making objects and surfaces move, change shape, ambient animation etc.
        - Renderer uses original bounds.
    - World Displacement
        - Similar to world position offset.
        - uses tesselation vertices rather than the base mesh vertices.
        - Material must have tesselation enabled.
    - Tesselation Multiplier
        - Controls amount of tesselation.
    - Subsurface Color
        - Simulates shifts in color of light as it passes through the surface.
        - Must have Subsurface Shading Model.
    - Ambient Occlusion
        - Simulates self-shadowing.
        - AO Map
    - Refraction
        - Simulates refraction index.
    - Clear Coat
        - Requires clear coat shader models.
        - Amount of clear layer
        - No CC Layer = 0.0 (black)
        - Full CC Layer = 1.0 (white)
    - Clear Coat Roughness
        - Roughness of the clear coat.

Material Instances

https://docs.unrealengine.com/latest/INT/Engine/Rendering/Materials/MaterialInstances/index.html

- Can be changed without recompilation or at runtime.
- Material Parameters:
    - Parameters can be exposed to Material Instance Editor, Blueprints and code.
    - Designate properties as editable through parameters:
        - Right Click on Node> Convert to Parameter
        - Search in Pallet > Drag into Graph
        - Right Click on Graph > Search in Context Menu
    - Material Instance Constant:
        - Instanced Material which only calculates once prior to runtime.
        - Same runtime performance as regular materials.
        - Allows for variation of a base material.
        - Right Click on a Material > Create Material Instance
        - Material Instance Editor:
            - Double Click on a Material Instance.

        - Allows you to edit the parameters of the Material Instance.
    - Material Dynamic Instance:
        - Instanced Material which can recalculated during runtime.
        - Parameters can be altered at runtime by Blueprints and C++ code:
            1) Create Dynamic Material Instance from a Material reference.
            2) Feed output into Set Parameter nodes.
            3) Feed output into mesh's Set Material node.
    - Parameter Groups
        - Allow for organization in the Material Instance Editor.
        - Select Parameter Node > Properties > Assign to Group
    - Parameter Types:
        - Scalar Parameter
            - Float value
        - Vector Parameter
            - 4 Channel vector
            - RGBA, position, etc.
        - Texture Parameter
            - Several textures parameters for different types of texture data.
        - Static Parameter
            - Only applied at compile time.
            - Only editable through Material Instance Editor.
            - Produce more optimal code.
    - Material Parameter Collections
        - Allow for sets of shared parameters between Material Instances.
        - Tool for using global data in many Materials at once.
        - Useful for level wide effects: Snow amount, wetness, wind strength/direction, etc.
        - Content Browser Right Click > Materials & Textures > Material Parameter Collection
        - Double click on Material Parameter Collection asset to open editor.
        - Can add arbitrary # of scalar or vector parameters.
        - Materials can reference up to two Material Parameter Collections.
        - Typical setup is one Material Parameter Collection for game-wide values, and another for level-specific effects.
        - To use, drag a Material Parameter Collection into Material Graph and connect to the Material Expression Network.
        - Use a Set Scalar/Vector Parameter node to control with blueprints.

Material Functions

https://docs.unrealengine.com/latest/INT/Engine/Rendering/Materials/Functions/index.html

- Self contained Material Expression graphs.
- Content Browser > Add New > Materials & Textures > Material Function
- Output Node
- Input Node
- Publish to Library:
    - Deselect all Nodes > Details > Expose to Library
- MakeMaterialAttributes

        - Outputs a complete material.
        - Feed into Output Result Node.
    - BreakMaterialAttributes

Layered Materials

https://docs.unrealengine.com/latest/INT/Engine/Rendering/Materials/LayeredMaterials/index.html

- A single material which has a series of sub-materials (layers) that can be placed across a surface using per-pixel operations, such as masks.
- Perfect for handling complex blending between unique surface types.
- Performance Intensive.
- Use Material Functions
- Create Material Layer:
    1. Create a new Material and tweak to perfection.
    2. Create a new Material Function from Content Browser.
    3. Copy all the nodes from the Material and paste in Material Function.
    4. Connect network to a MakeMaterialAttributes node.
    5. Save the Function.
    6. Drag the Material Function into the Material Editor.
    7. Blend multiple layers using Material Layer Blend Functions.
- Material Layer Blend Functions
    - Pallet > MaterialLayerBlend > Choose Blend Type > Drag onto Graph
    - Allow for specialized blends.
- Instancing
    - Feed top level parameter into function input.