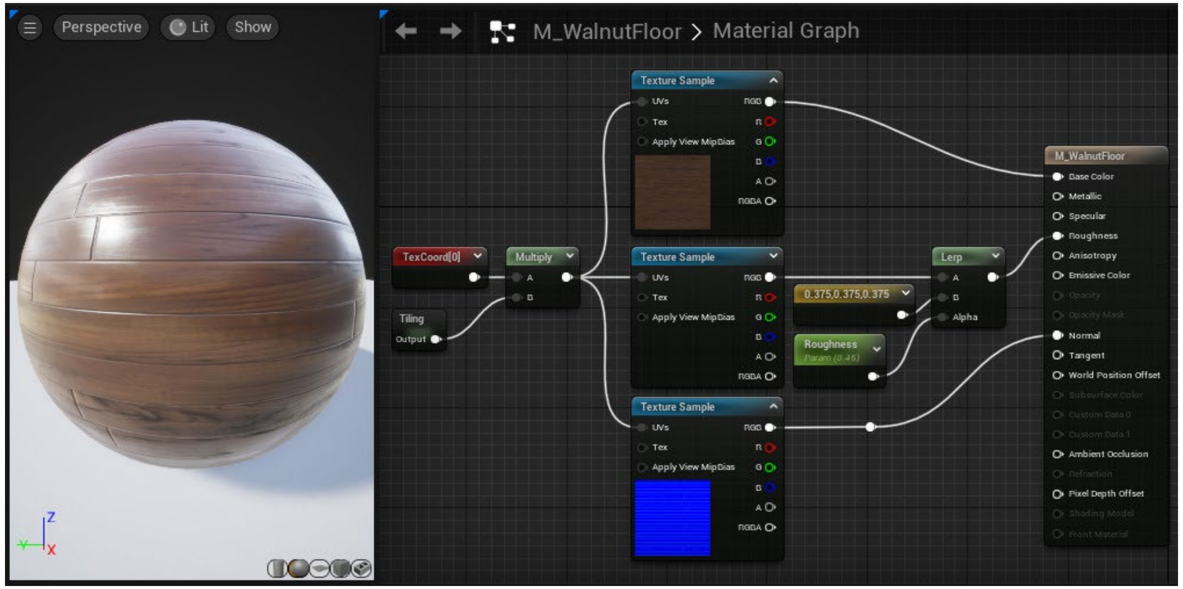
Rendering

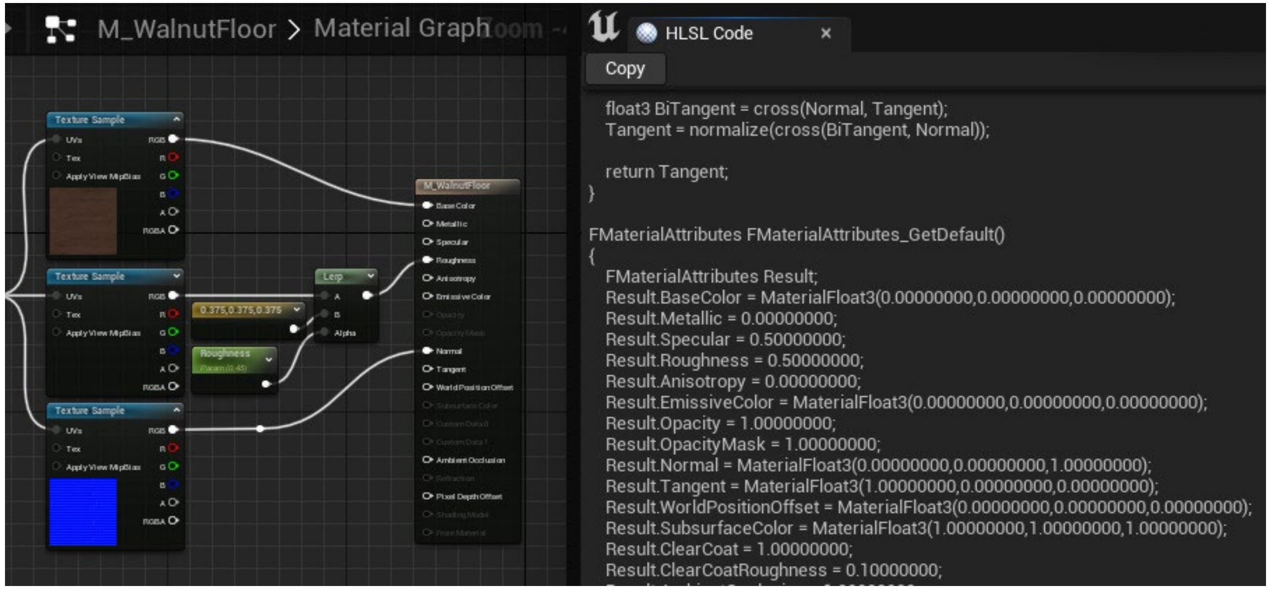
UE5 Material Model

CS 415: Game Development

Professor Eric Shaffer

Shading Pipeline Overview





```
   float3 BiTangent = cross(Normal, Tangent);
   Tangent = normalize(cross(BiTangent, Normal));

   return Tangent;
}

FMaterialAttributes FMaterialAttributes_GetDefault()
{
   FMaterialAttributes Result;
   Result.BaseColor = MaterialFloat3(0.00000000,0.00000000,0.00000000);
   Result.Metallic = 0.00000000;
   Result.Specular = 0.50000000;
   Result.Roughness = 0.50000000;
   Result.Anisotropy = 0.00000000;
   Result.EmissiveColor = MaterialFloat3(0.00000000,0.00000000,0.00000000);
   Result.Opacity = 1.00000000;
   Result.OpacityMask = 1.00000000;
   Result.Normal = MaterialFloat3(0.00000000,0.00000000,1.00000000);
   Result.Tangent = MaterialFloat3(1.00000000,0.00000000,0.00000000);
   Result.WorldPositionOffset = MaterialFloat3(0.00000000,0.00000000,0.00000000);
   Result.SubsurfaceColor = MaterialFloat3(1.00000000,1.00000000,1.00000000);
   Result.ClearCoat = 1.00000000;
   Result.ClearCoatRoughness = 0.10000000;
```

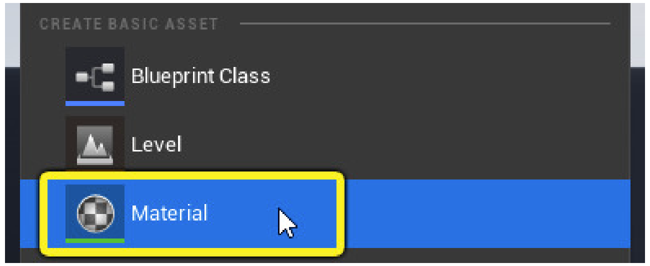
- Shaders are programs that define how each vertex or pixel should be rendered.
- Shaders in Unreal Engine are written in High Level Shading Language (HLSL).
- Shader code is converted to Assembly Language instructions that the GPU hardware can execute.
- In the Unreal Editor you do not need to write HLSL code to create shaders for your project.
- You can create assets called **Materials** in a visual scripting interface called the **Material Editor**.

Creating New Materials

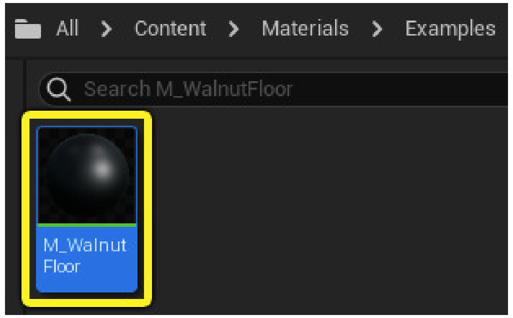
Materials in Unreal Engine are an asset class just like Static Meshes, Textures, or Blueprints.

You can create new Materials from the Content Browser.

1. Right-click in the **Content Browser**
2. Select **Material** in the **Create Basic Asset** setion of the context menu.

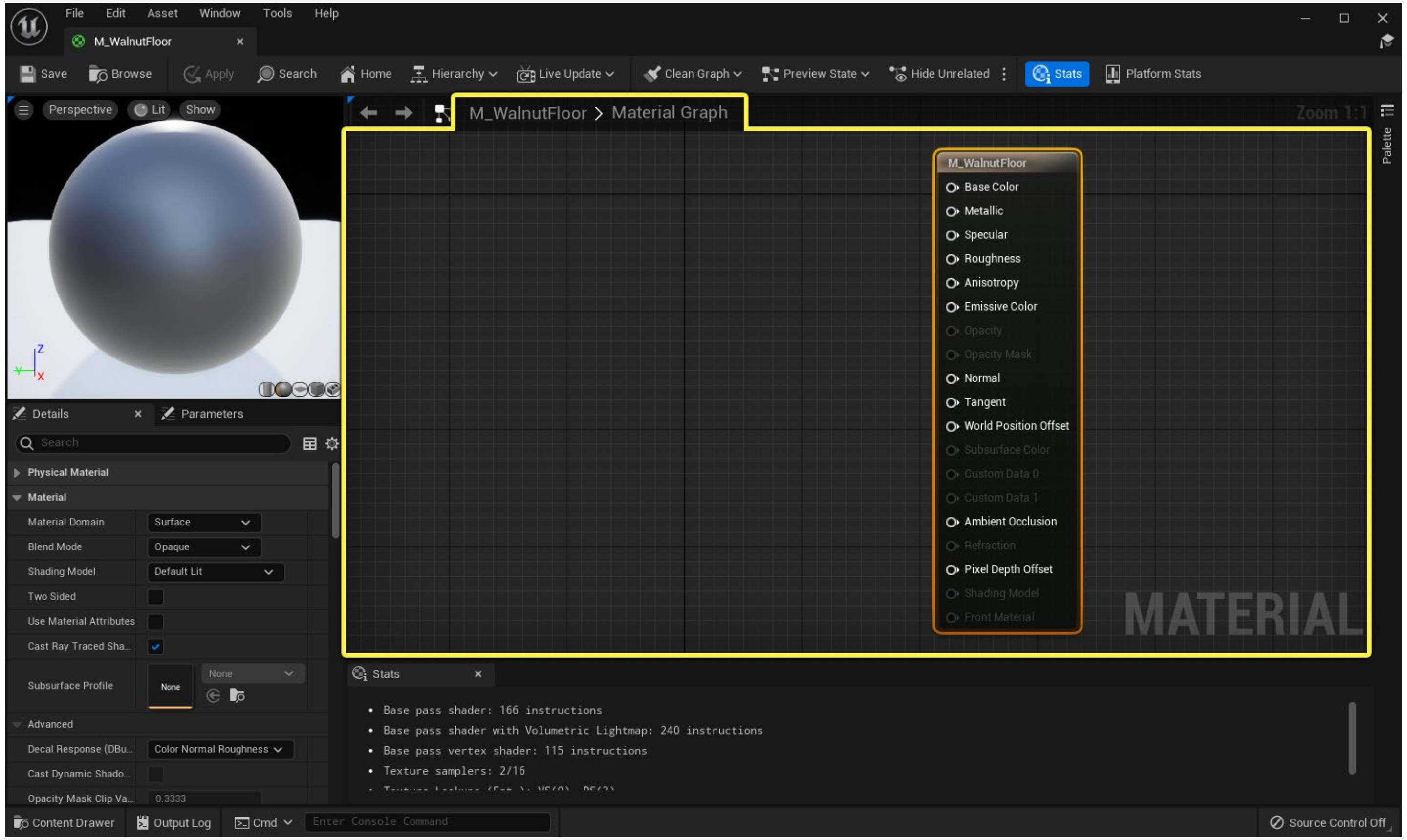


3. A Material is created in the Content Browser. Give it a unique and descriptive name.



Creating New Materials

Double-click the Material asset to begin editing the Material.
The Material Editor window opens as shown below.

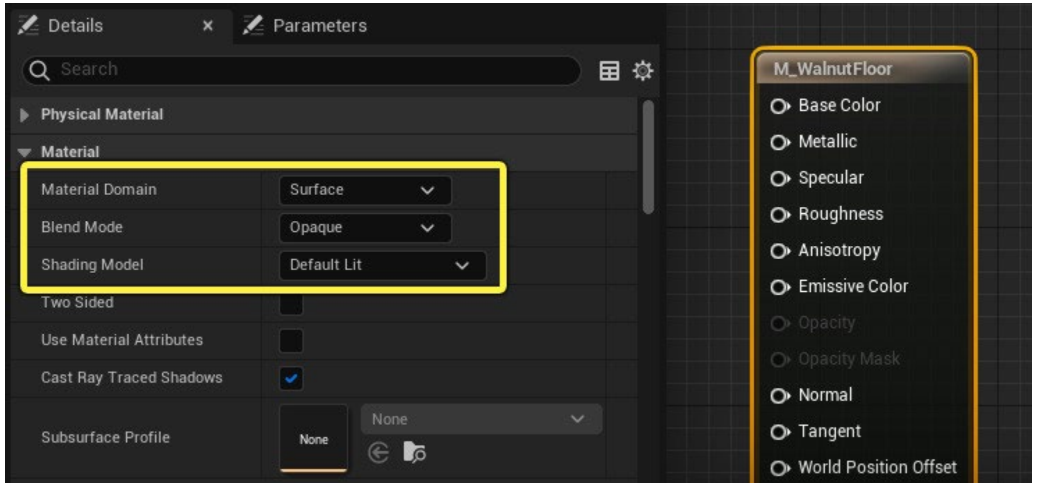


Material Domain	Surface
Blend Mode	Opaque
Shading Model	Default Lit
Two Sided	□
Use Material Attributes	□
Cast Ray Traced Sha...	☑
Subsurface Profile	None
Decal Response (DBu...	Color Normal Roughness
Cast Dynamic Shado...	□
Opacity Mask Clip Va...	0.3333

```
• Base pass shader: 166 instructions
• Base pass shader with Volumetric Lightmap: 240 instructions
• Base pass vertex shader: 115 instructions
• Texture samplers: 2/16
• Texture Lookups (Est.): VS(0), PS(2)
```

Material Properties

When the **Main Material Node** is selected, the global Material properties and settings display in the **Details panel**.



Material Domain	Surface
Blend Mode	Opaque
Shading Model	Default Lit
Two Sided	□
Use Material Attributes	□
Cast Ray Traced Shadows	☑
Subsurface Profile	None

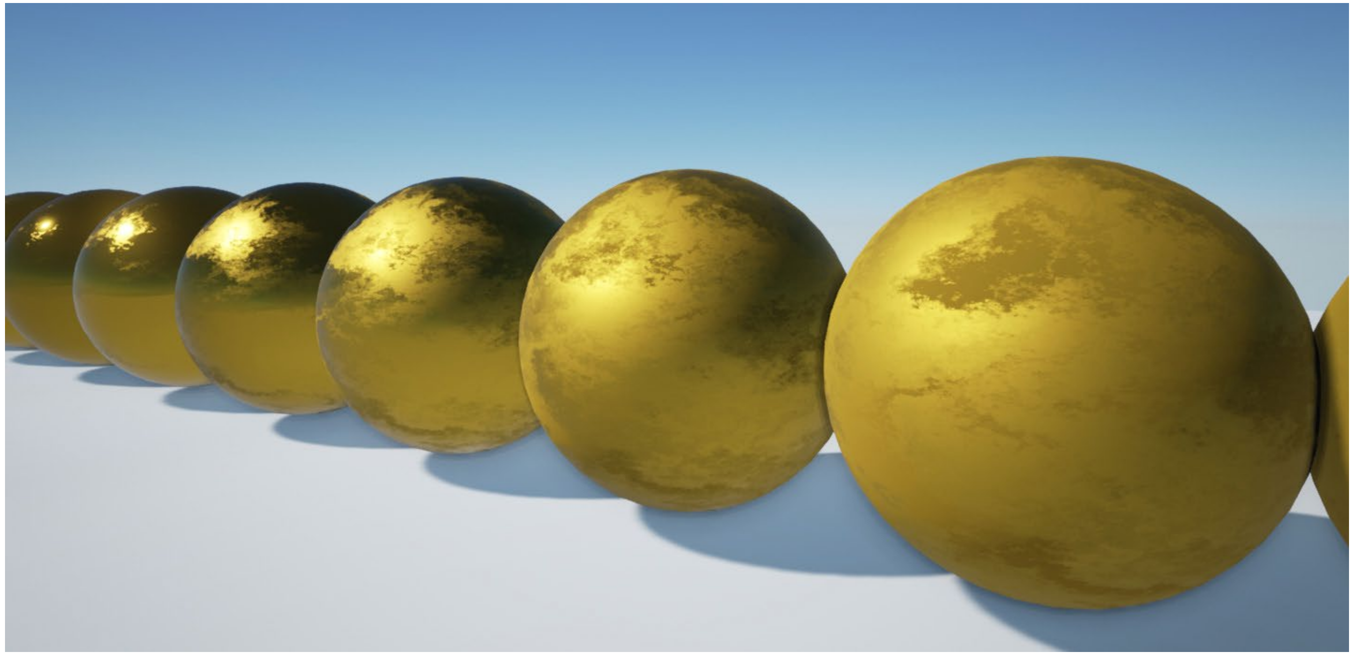
- **Material Domain** – Defines what the Material will be used for in your project.
  For example, Surface, User Interface, and Post-process Materials are different Material Domains.
- **Blend Mode** – Defines how the Material blends with the pixels behind it.
  For example, **Opaque** shaders completely occlude objects behind them.
  Translucent and **Additive** shaders blend with the background in some way.
- **Shading Model** – Defines how the Material interacts with light.
  Most Materials will simply use the Default Lit shading model.
  UE includes specific Shading models for things like **Hair**, **Cloth**, and **Skin**

Physically Based Materials

PBR Material Attributes

- Base Color
- Roughness
- Metallic
- Specular

UE Material model has more attributes
These are the ones related to PBR shading

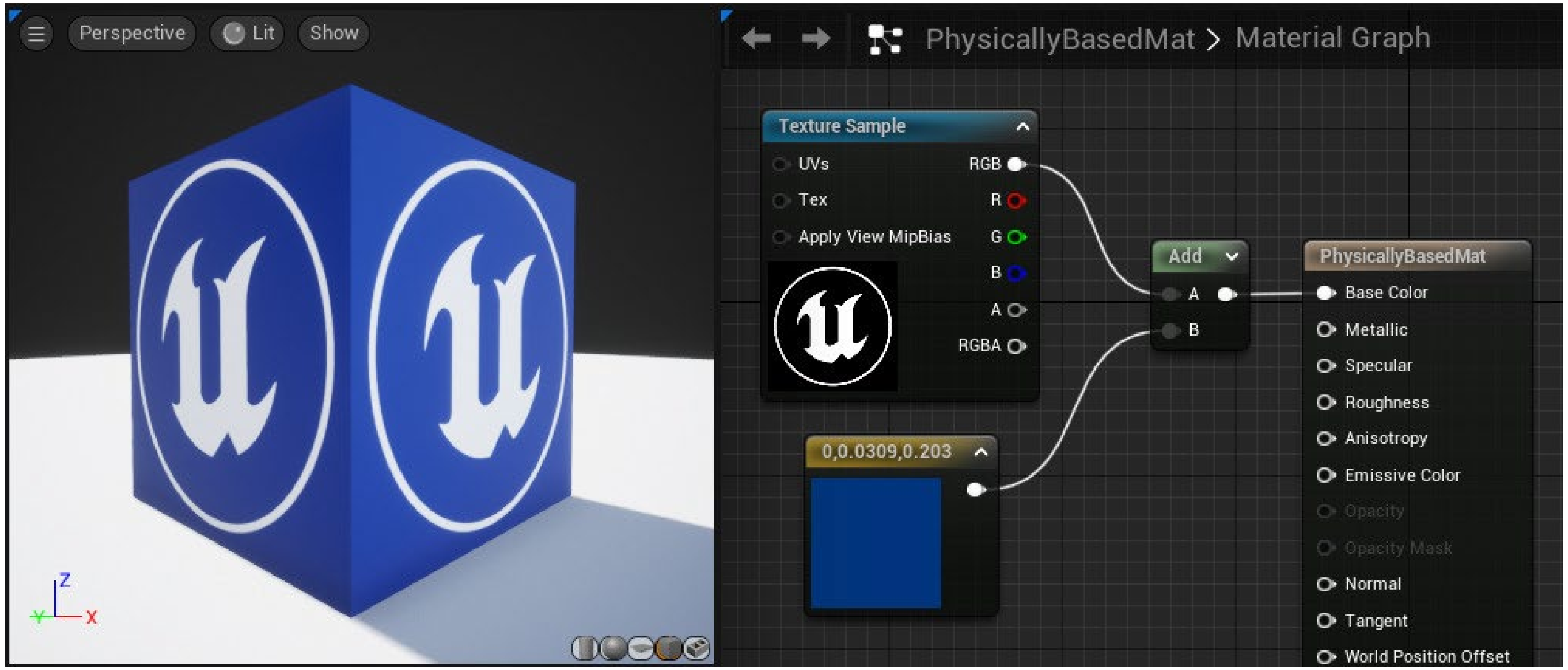


All of these inputs are designed to accept values between 0 and 1.

In the case of Base Color this means a color or texture sample

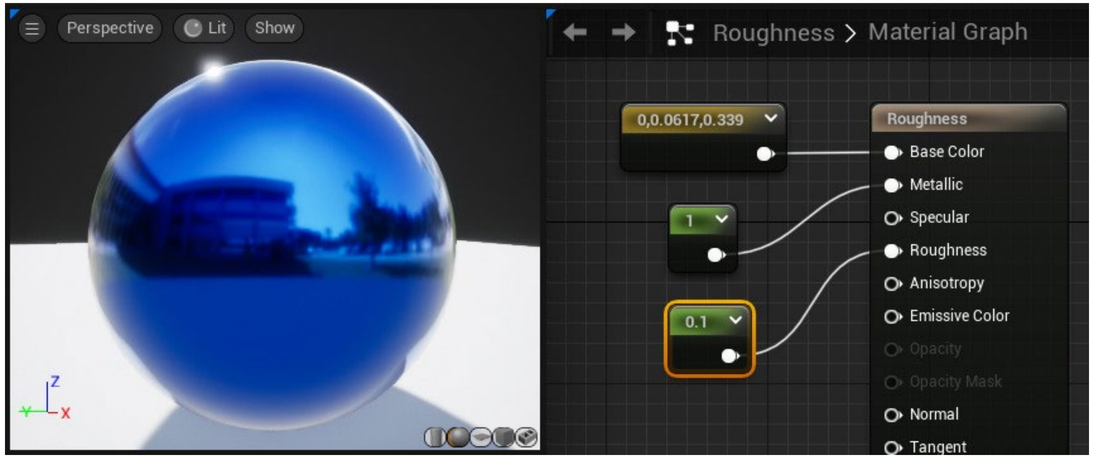
- RGB values that fall between 0 and 1

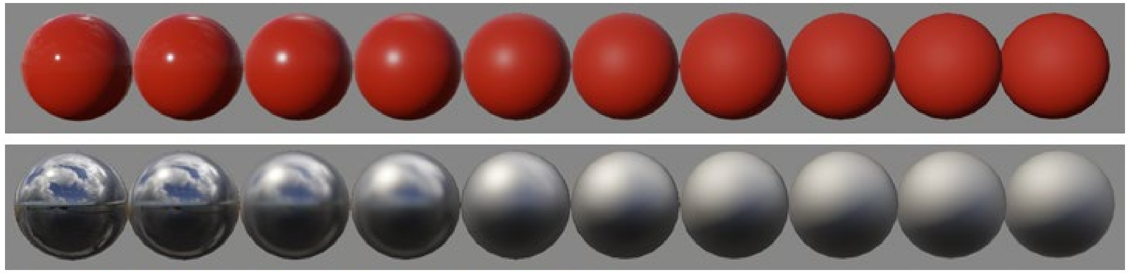
Base Color



Base Color defines the overall color of the Material.
The Base Color input accepts a **Vector3 (RGB)** value
Each channel is automatically clamped between 0 and 1.

Roughness

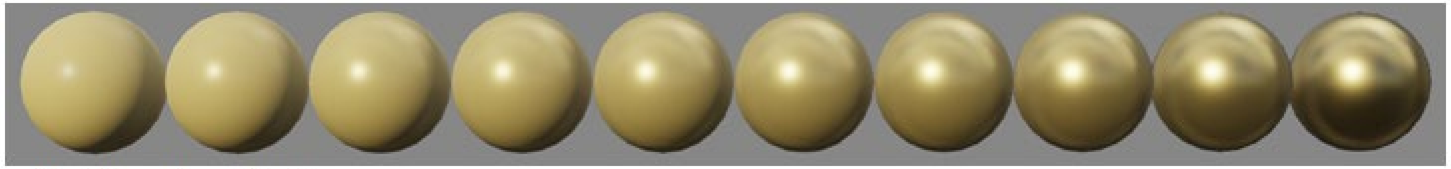




Roughness values from 0 to 1. Nonmetal top, metal bottom.

- The Roughness input controls how rough or smooth a Material's surface is. In the Material this manifests as how sharp or blurry reflections appear on the Material.
- Rough Materials scatter reflected light in more directions than smooth Materials, which results in diffuse reflections. Smooth surfaces reflect light more in more focused directions, resulting in clear reflections or specular highlights.
- A Roughness of 0 (smooth) results in a mirror reflection.
- A Roughness of 1 (rough) results in a diffuse or matte surface.

Metallic



Metallic values 0 to 1.

- The Metallic input accepts a value between 0 and 1
  Defines whether your Material behaves as a metal or nonmetal.
- In most cases, you should treat Metallic as a binary property
  - For pure surfaces, such as pure metal or pure stone set Metallic to **either 0 or 1**
  - Hybrid surfaces like corroded or dusty metals, need a value between 0 and 1

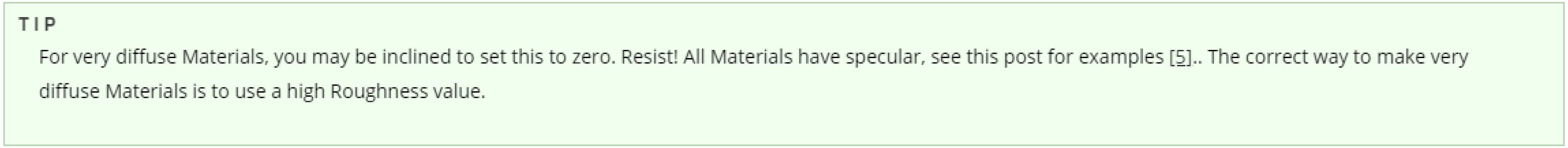
Mapping Metallic

- Metals and nonmetals are often present in the same Material.
  - Consider a metal panel, with a coat of paint covering some of the metal.

- Paint is a nonmetal, Metallic value should be 0 in any regions covered by paint.
- Anywhere the metal panel is visible, the Metalic value should be 1.
- This should be handled with a black and white mask passed into the Metallic input.
- Paint does not blend with metal, it sits on top of it.
- Your Metallic map should not contain grayscale values, only black and white.
- You could also use Material Layers to achieve similar results.

Specular

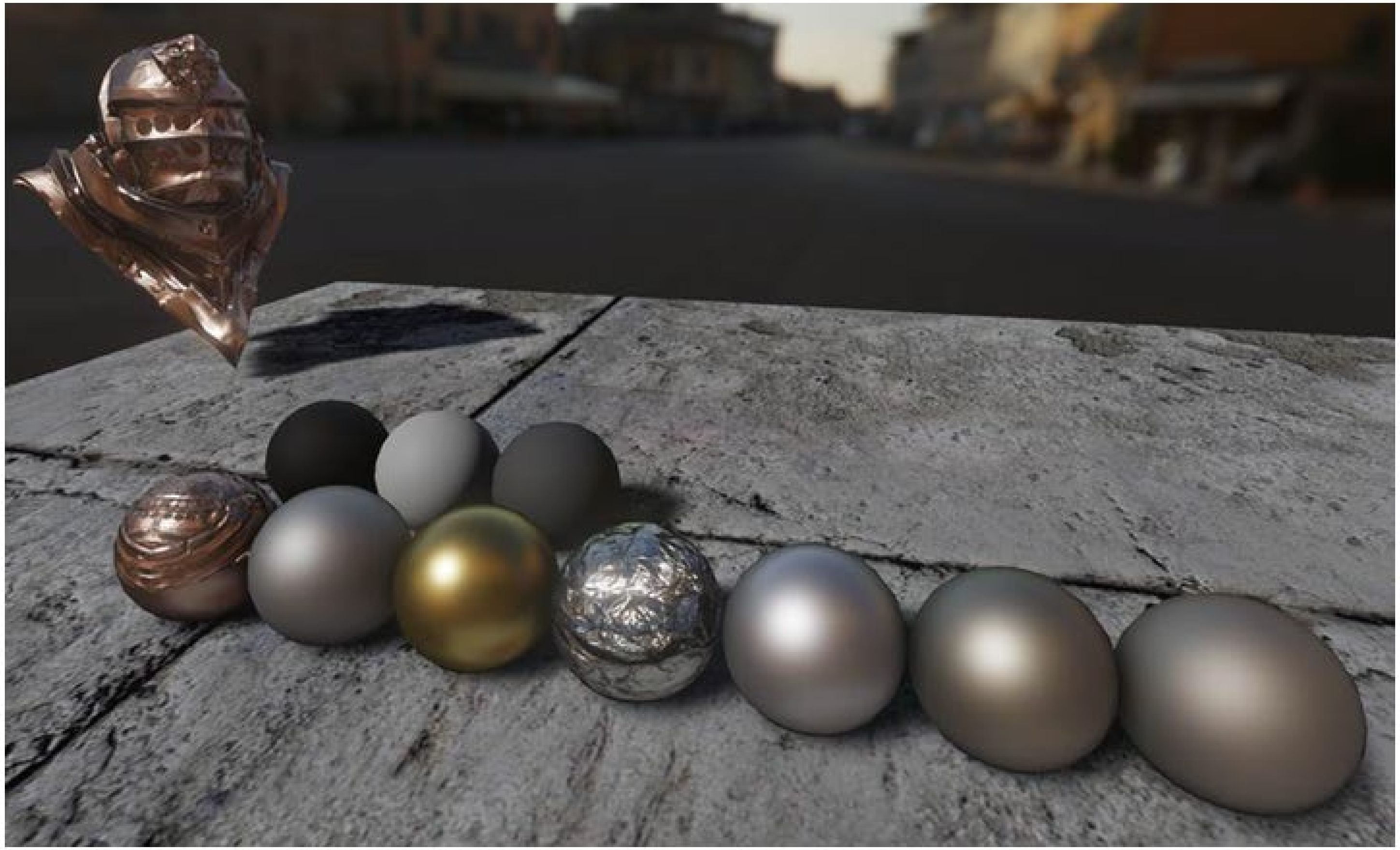
- The Specular input controls how much specular light the surface reflects.
  - A Specular value of 0 is fully non-reflective.
  - A Specular value of 1 is fully reflective.
  - Unreal Engine uses a **default Specular of 0.5**,
    - Represents approximately 4% specular reflection.
    - This value is accurate for a vast majority of materials.
- **Specularity** refers to the amount of specular light reflected by a surface.
- The Specular input is **not used for reflection maps** or to add surface variation. These should be handled in the Roughness map.



TIP

For very diffuse Materials, you may be inclined to set this to zero. Resist! All Materials have specular, see this post for examples [5].. The correct way to make very diffuse Materials is to use a high Roughness value.

Examples



Example measured Materials. Top: Charcoal, fresh concrete, worn asphalt. Bottom: Copper, iron, gold, aluminum, silver, nickel, titanium