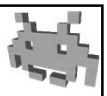
Course Plan



lec. 1: **Introduction**
lec. 2: **Mathematics** for 3D Games
lec. 3: **Scene Graph**
lec. 4: Game **3D Physics** + **Particle Systems**
lec. 5: Game **Particle Systems**
lec. 6: Game **3D Models**
lec. 7: Game **Textures**
lec. 8: Game **3D Animations**
lec. 9: Game **Materials** ADDENDUM
lec. 10: **Networking** for 3D Games
lec. 11: **Artificial Intelligence** for 3D Games
lec. 12: **3D Audio** for 3D Games
lec. 13: **Rendering Techniques** for 3D Games

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Choice of material models: Chapter 2 ('00s)

Main reasons:
1. more GPU processing power affords us more realism.
2. Programmable shaders.
3. More GPU RAM to store textures for parameters

- The Lighting Equation becomes more complex
  - more terms are added
- It feeds on more material parameters…
  - Factors for: Fresnel effect, Anisotropic effect, Reflectivity – with environment maps, …
- Authoring materials becomes an increasingly complex, and *ad-hoc,* task
  - Difficult to port one material …
    - …from one engine to another, …from one game to another, …from one asset to another
  - Difficult to guess the right parameters for a given object
    - especially if it has to look good under widely different lighting conditions

the task of the "material artist"

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Much wider expressiveness is needd

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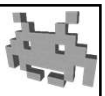
Material models improving



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Material models are improving

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Choice of material models: Chapter 3 ('10s to today)

- Physically Based Materials (PBM)
  - an ongoing trend!
- General characteristics and objectives:
  - increased intuitiveness:
    - provide Material Artist with a higher-level material description
    - eases the Material Authoring task
  - increased standardization:
    - makes materials more cross-engine / portable (almost)
  - increased generality:
    - accommodates for more lighting effects / types of materials, such as Fresnel or anisotropic materials…
  - increased realism / quality:
    - more faithful, physically justified model of real-world materials
    - it's possible to capture materials from real-world samples
    - rendering results look better under widely different lighting env

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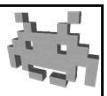
«Physically Based Lighting» (PBL)



- A lighting model more inspired more by physical reality
  - For example, energy conservation
  - And less by tricks that just follow some intuition, see specular Phone reflections
- A lighting model accepting, as input, a PBM
- Also, a lighting model taking fewer shortcuts than otherwise typical
  - For example, use
    - diffuse color: *one* texture
    - baked AO: *a separate* texture
  - Instead of:
    - diffuse color × baked AO : one texture (cheaper!)
- Warning: PBM & PBL are, basically, buzzwords ☺

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PBM and PBL: objectives

- Make realistic materials easier to design (by material artists)
- Make it possible to *capture* materials from real world samples
- Make it easier to make lighting look reasonably realistic… under many different lighting environment
- Standardize, and make it easier to share material description across different project applications
- Ideally: most real-world materials can be described accurately
- Ideally: no combination of Material parameters looks bad or wrong
- Use few parameters (ease storage, authoring), every parameter describe in a 0 to 1 range

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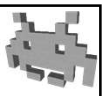
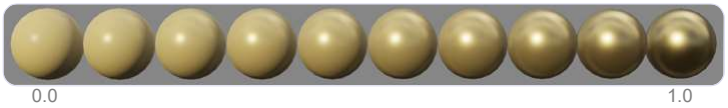
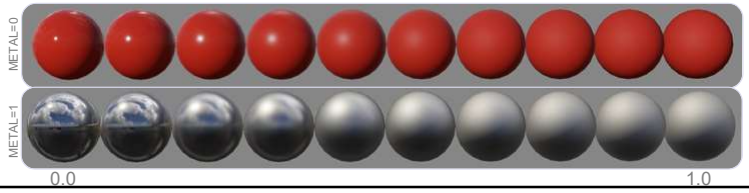
Physically Based Materials (PBM). A good choice of parameters



- Base color (rgb – or "diffuse", same as old school)
- Specularity (scalar – or rgb sometimes)
- "Metallicity" (scalar)



- Roughness (scalar)



images: unreal engine 4

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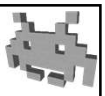
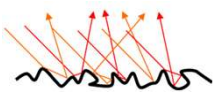
Physically Based Materials (PBM)



- Base color: (a color)
  - Same as in base lighting model
- Specularity: (a scalar, in 0 to 1)
  - Total amount of light bouncing off the surface with reflections (regardless of how).
  - Very rarely it's 0 or close. Although in different ways, "everything is shiny."
- Metallicity (or metallosity): (a scalar, in 0 to 1)
  - Is the surface a (conductive, dielectric) material or not?
  - In theory, either 0 or 1, but it's possible to interpolate results.
- Roughness: (a scalar, in 0 to 1)
  - Low = 
  - High = 

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