Introduction to Ray Tracing

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SIGGRAPH 2021

Ray Tracing

Rajesh Sharma

Today

- Introduction
- Guest: Peter Shirley
- What is Ray Tracing?
- How does a camera work?
- Properties of lights and materials
- Sampling a function

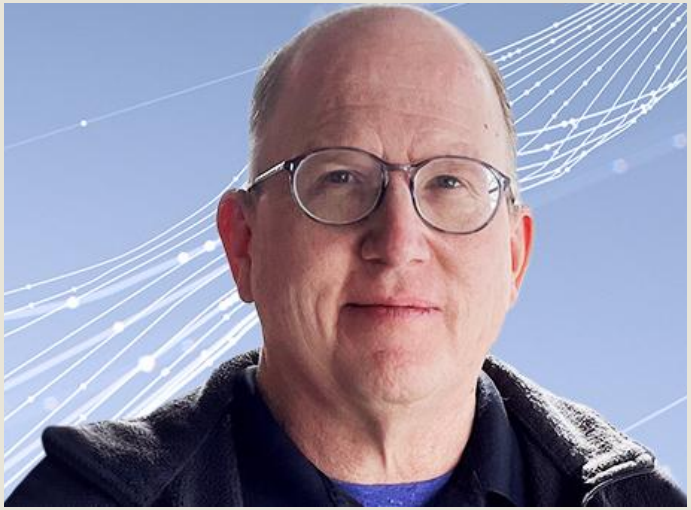
Course Outline

-- Intro, Model, Sampling
-- Rays, Intersections
-- Scene, Recursion
-- Materials, BRDF
-- Importance Sampling, Lights
-- Systems View: Integrators, Accelerators
-- Wrap up, Learn more

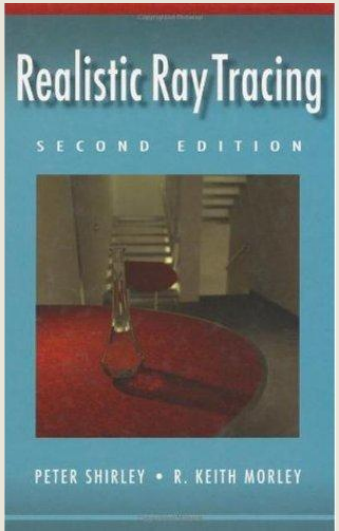
Housekeeping

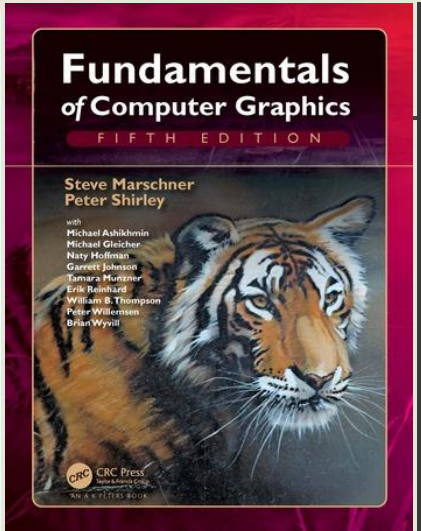
- Link to today's slides and Colab notebooks:
  - Log in to your google drive
  - Make a shortcut to: https://bit.ly/3viTHez
  - Create an account on shadertoy.com
- Use the chat to ask questions, help others
- After the lecture: @xarmalarma, #siggraph2021

Peter Shirley



Researcher, Teacher, Author





Distinguished Scientist
NVIDIA

What is Ray Tracing?

$$L_r(x, \omega_r) = L_e(x, \omega_r) + \int_\Omega L_r(x', -\omega_i)\, f(x, \omega_i, \omega_r) \cos\theta_i d\omega_i$$

What is Ray Tracing?

What is Ray Tracing?

Image is formed from interaction of lights and materials

Depends on:

- Location of objects
- Location of lights
- Viewing Angle

We only see what's in front of us
But, it may be affected by what is not directly visible

What is Ray Tracing?

https://www.youtube.com/watch?v=frLwRLS_ZR0

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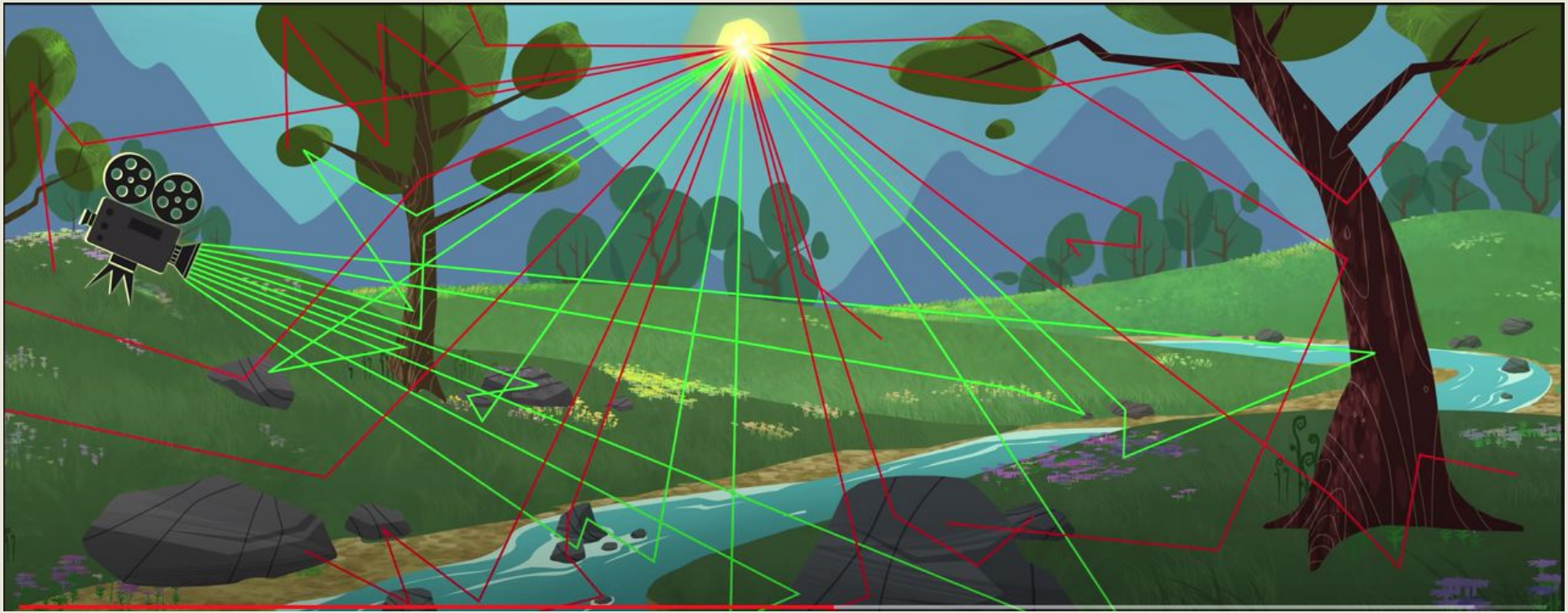
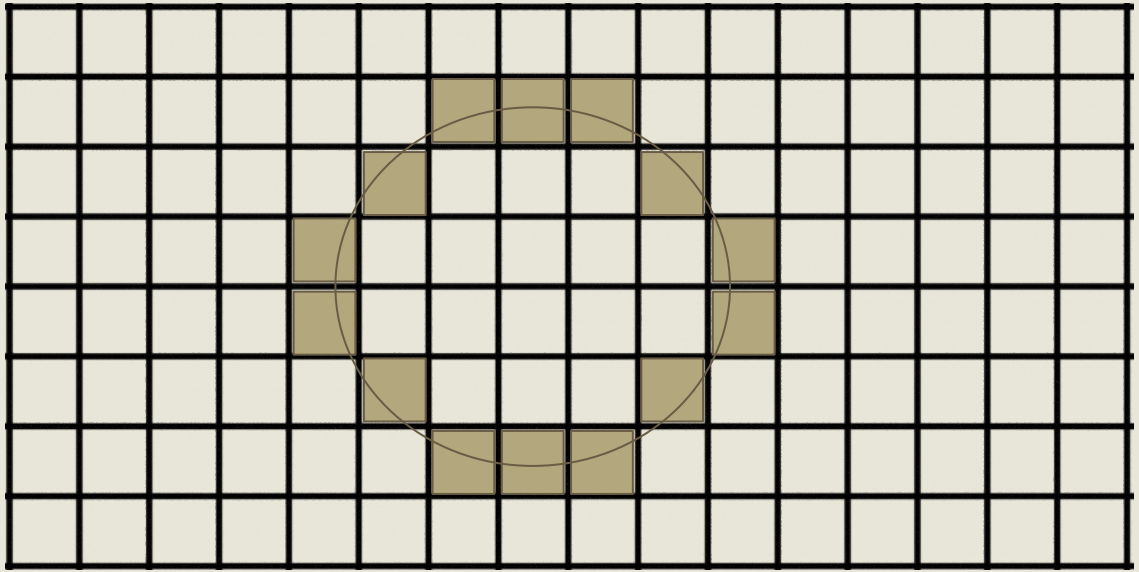


https://www.youtube.com/watch?v=frLwRLS_ZR0

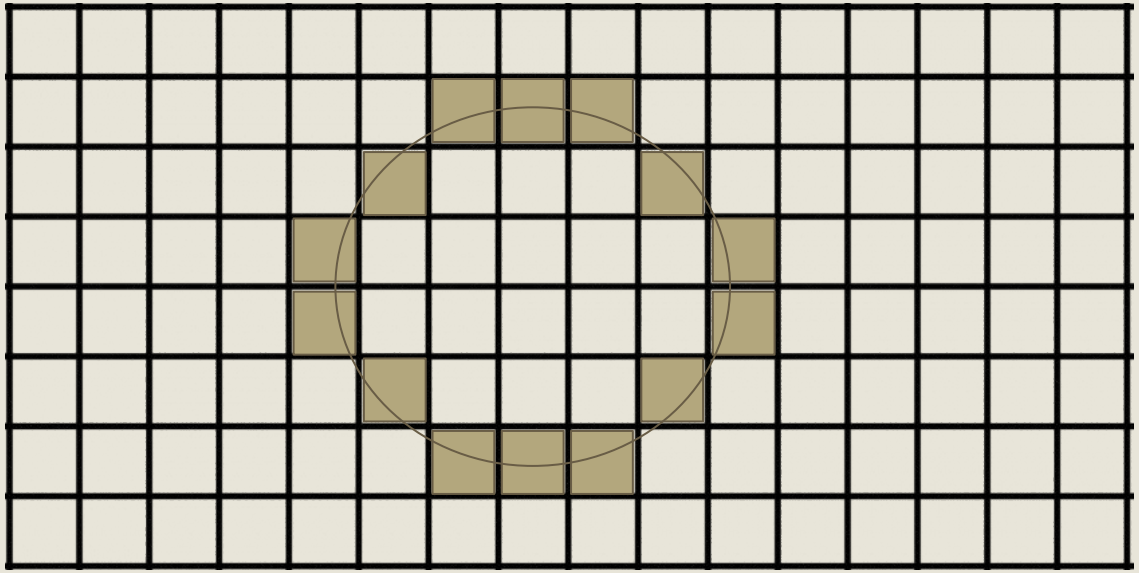
Sampling

- At each pixel, ask questions from an object
  - Do you exist?
  - What color are you?



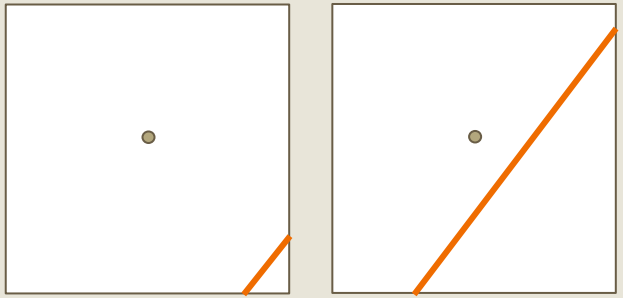
Sampling

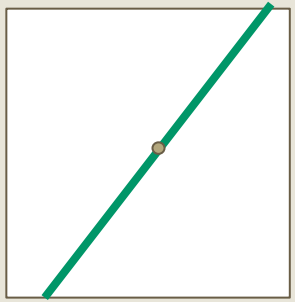
- Problem: Pixels are large and discontinuous, object is continuous

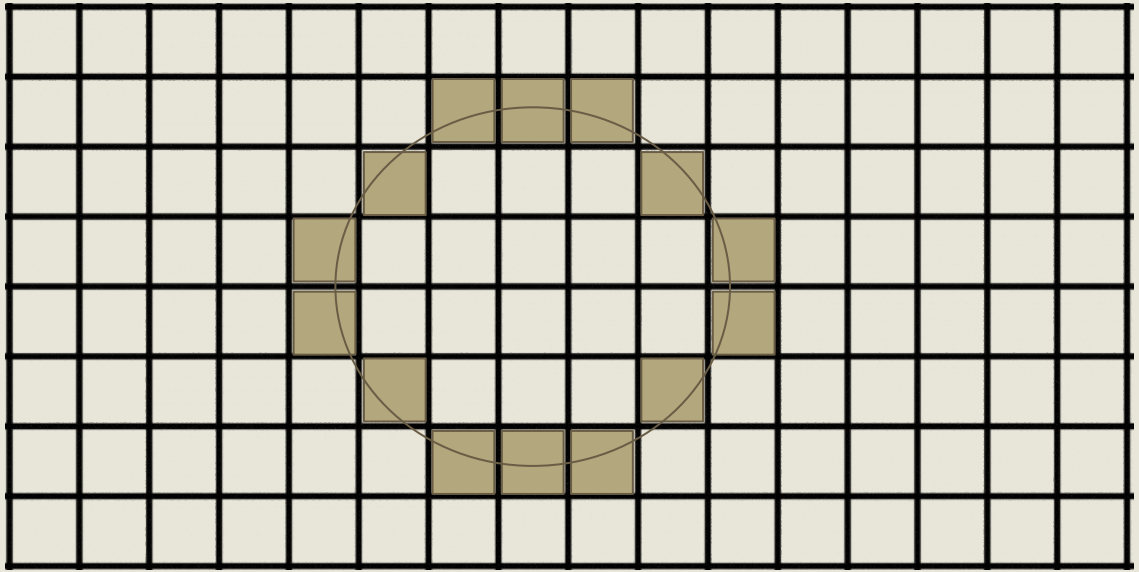


Sampling

- Problem: Pixels are large and discontinuous, object is continuous

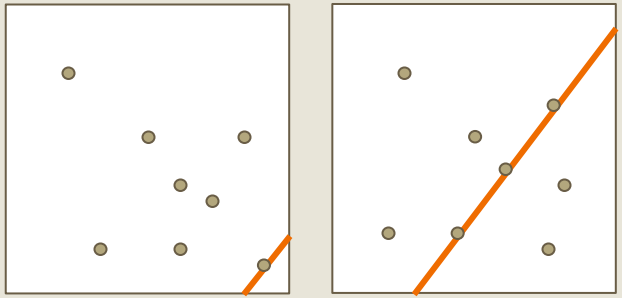


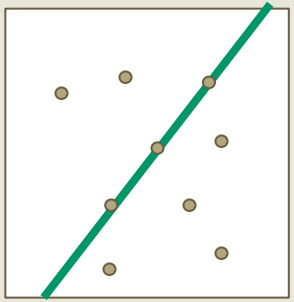


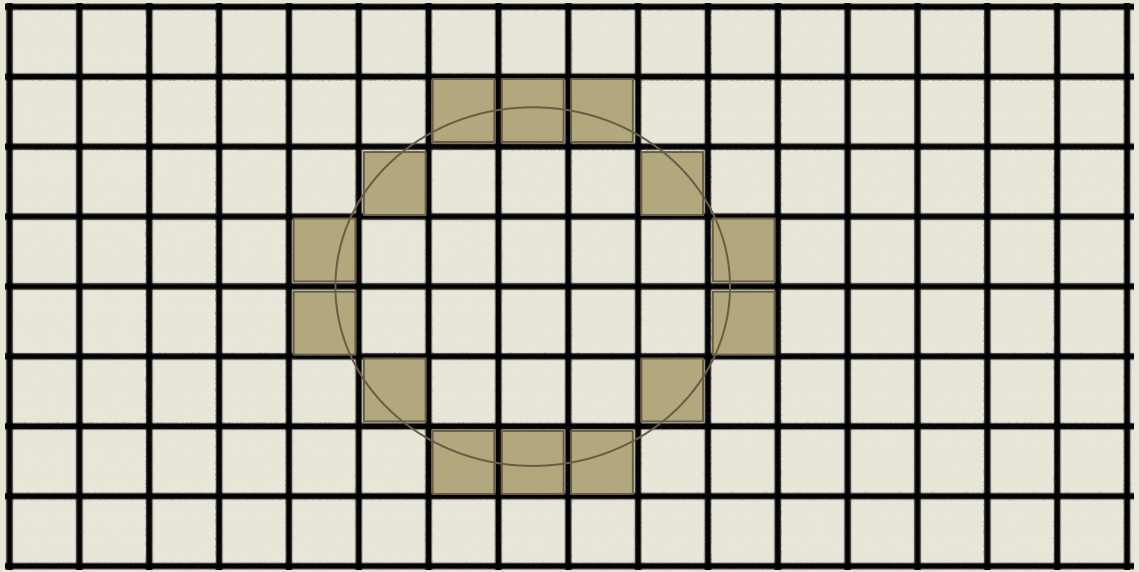


Sampling

- A solution: Multiple samples per pixel (Random)

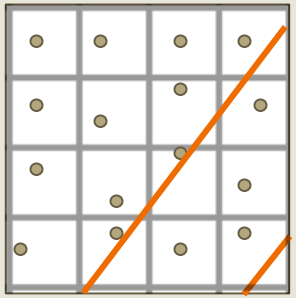




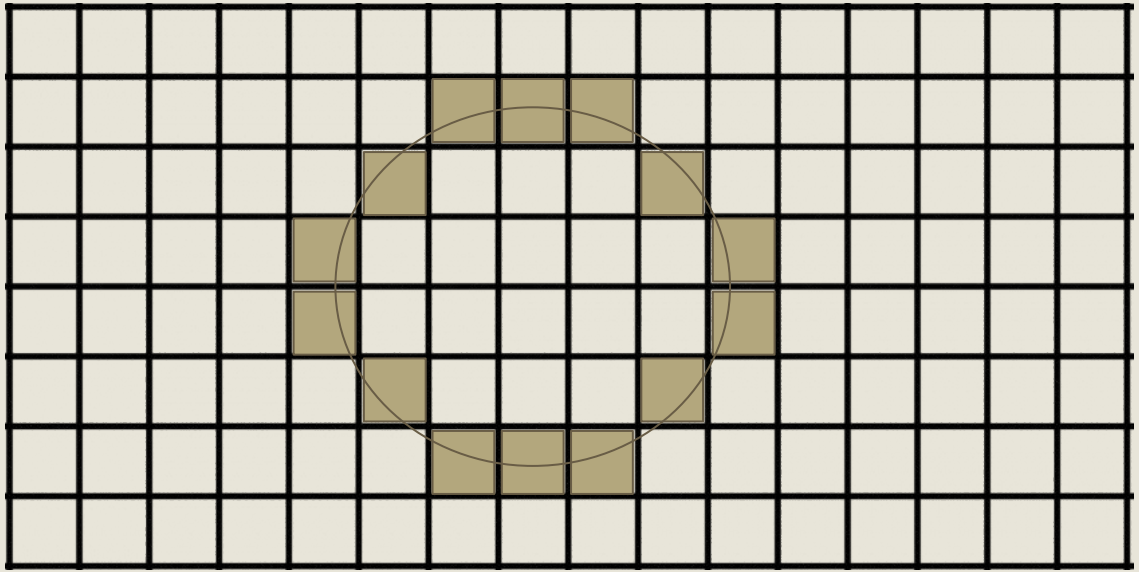


Sampling

- A (better) solution: Stratified/jittered multiple samples per pixel



Single Pixel



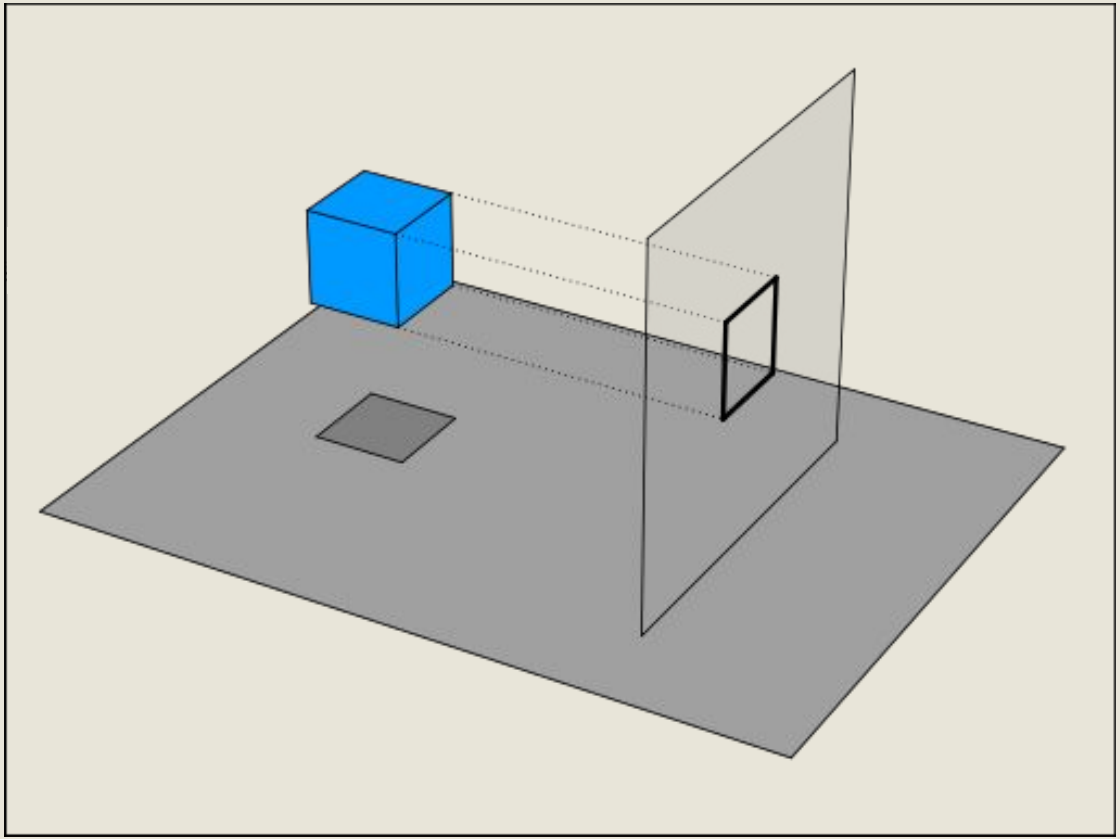
Hands-on

- ★ Log in to your google drive
- ★ Make a shortcut to: https://bit.ly/3viTHez
- ★ Create an account on shadertoy.com
- ★ Fork a copy of:
  - ○ https://www.shadertoy.com/view/sls3Rn

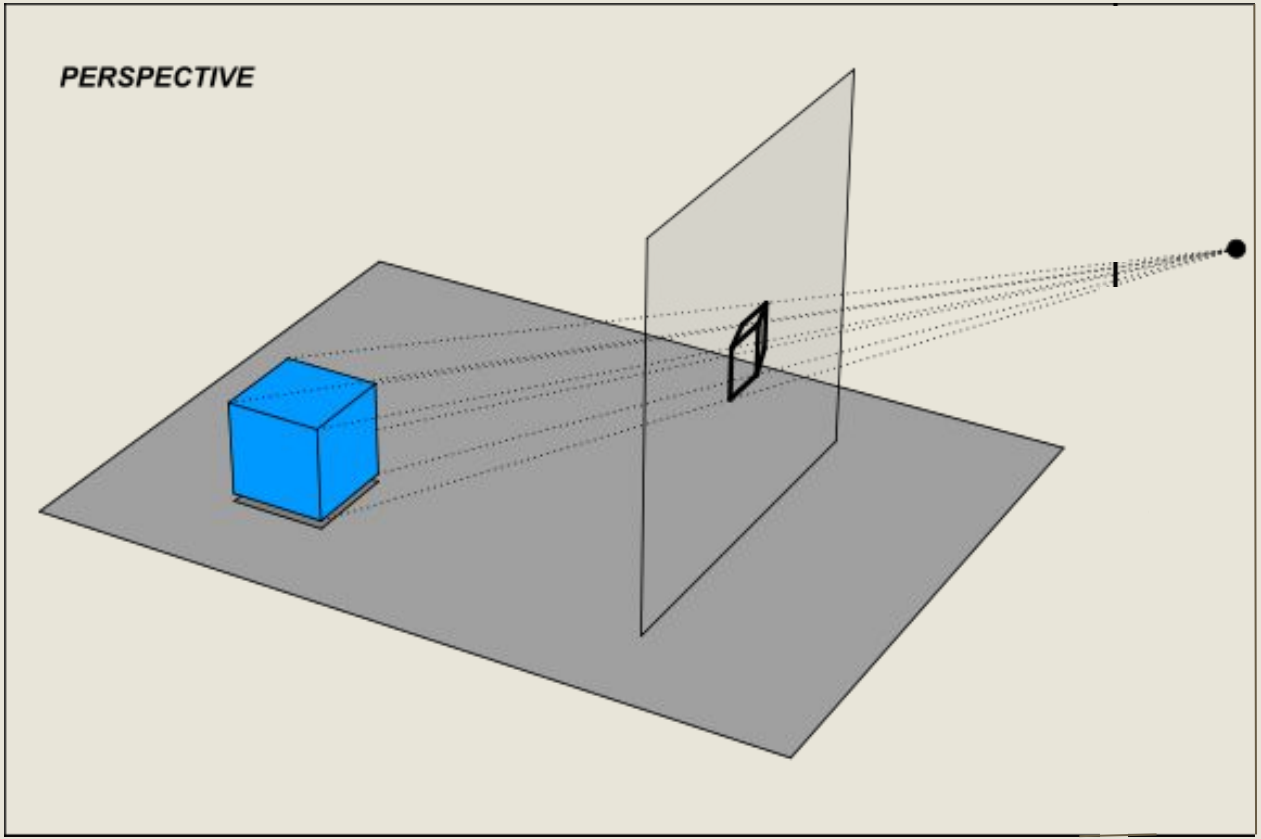
ShaderToy Basics

```
// Created by inigo quilez - iq/2014
// License Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License.

// The final product of some live coding improv. The process is live narrated in this
// video: https://www.youtube.com/watch?v=0ifChJ0nJfM

void mainImage( out vec4 fragColor, in vec2 fragCoord )
{
    vec2 p = fragCoord.xy / iResolution.xy;
    vec2 q = p - vec2(0.33,0.7);

    vec3 col = mix( vec3(1.0,0.3,0.0), vec3(1.0,0.8,0.3), sqrt(p.y) );

    float r = 0.2 + 0.1*cos( atan(q.y,q.x)*10.0 + 20.0*q.x + 1.0);
    col *= smoothstep( r, r+0.01, length( q ) );

    r = 0.015;
    r += 0.002*sin(120.0*q.y);
    r += exp(-40.0*p.y);
    col *= 1.0 - (1.0-smoothstep(r,r+0.002,
                 abs(q.x-0.25*sin(2.0*q.y))))*(1.0-smoothstep(0.0,0.1,q.y));

    fragColor = vec4(col,1.0);
}
```

Hands-on



Next Class



Next Class

- Rays, Spheres
- Intersections
- Homework:
  - Sample some interesting functions
  - Implement jittered/stratified sampling
  - @xarmalarma, #siggraph2021

QUESTIONS?

- Chat
- #xarmalarma