Lab #3 - Ray tracing (part 1)

Informática Gráfica

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Before we begin…

Graphics and Imaging Lab

- Requirements for this lab:
  - Points, directions, matrices and their operations

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  - Lab 3 (ray tracing) does not need to be submitted
    - Recommended deadline: **October 18th**

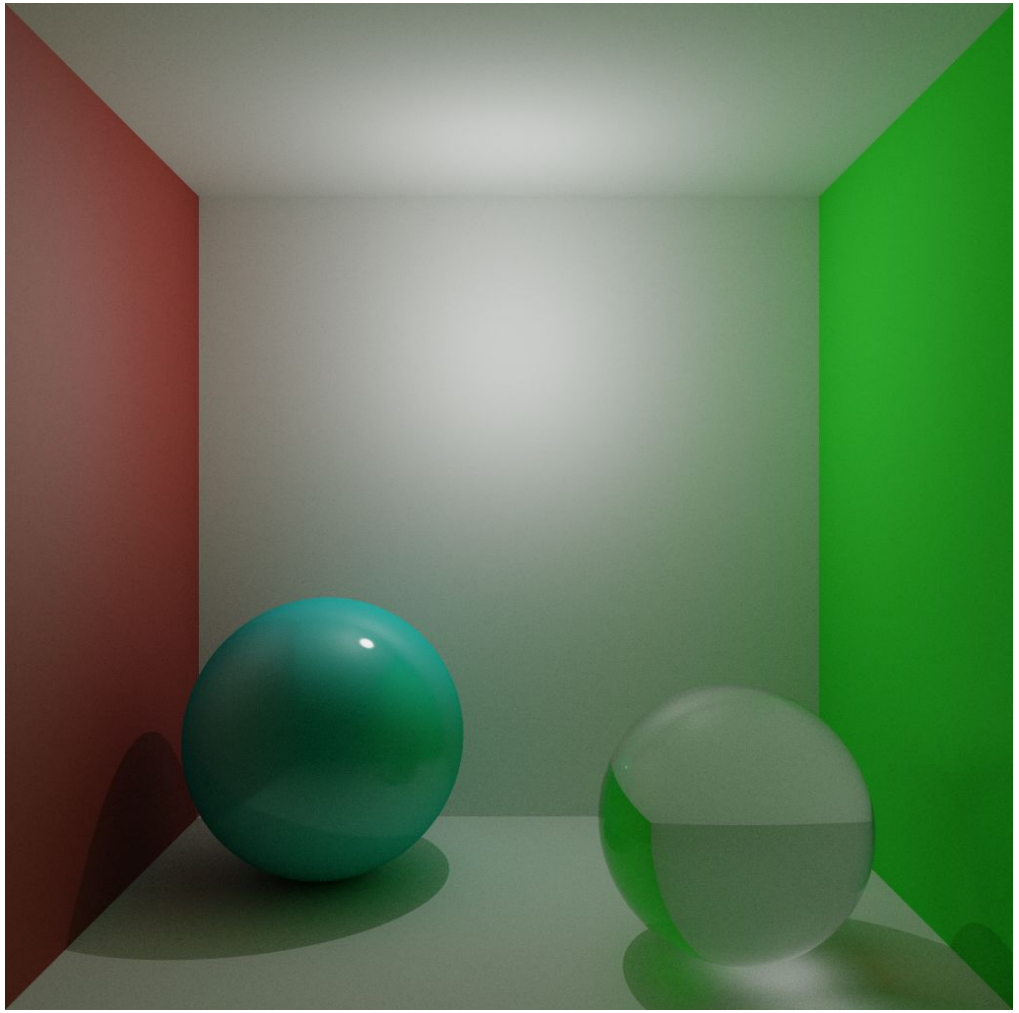
Before we begin…

Graphics and Imaging Lab

- Requirements for this lab:
  - Points, directions, matrices and their operations
- Careful with the submissions
  - Lab 3 (ray tracing) does not need to be submitted
    - Recommended deadline: **October 18th**
  - Lab 4 (path tracing) **will be submitted** at the end of the course
    - All of the code you write today will be used for Lab 4
    - Recommended deadline: November 13th (moodle: January 11th, this is only a recommendation)
- Remember: Final work is 80% of the final grade

Which color do we fill each pixel with?

Graphics and Imaging Lab



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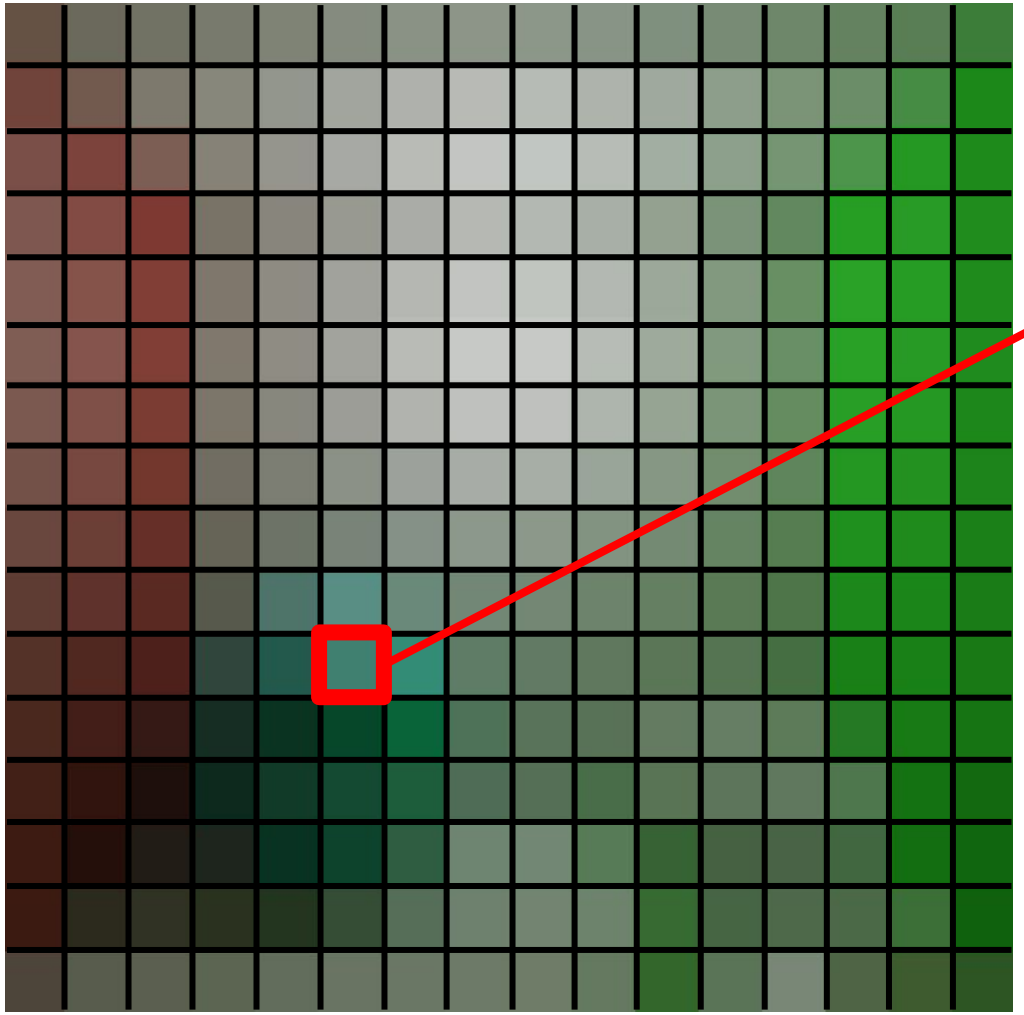

R = 0.25 G = 0.5 B = 0.45

But how?

Which color do we fill each pixel with?

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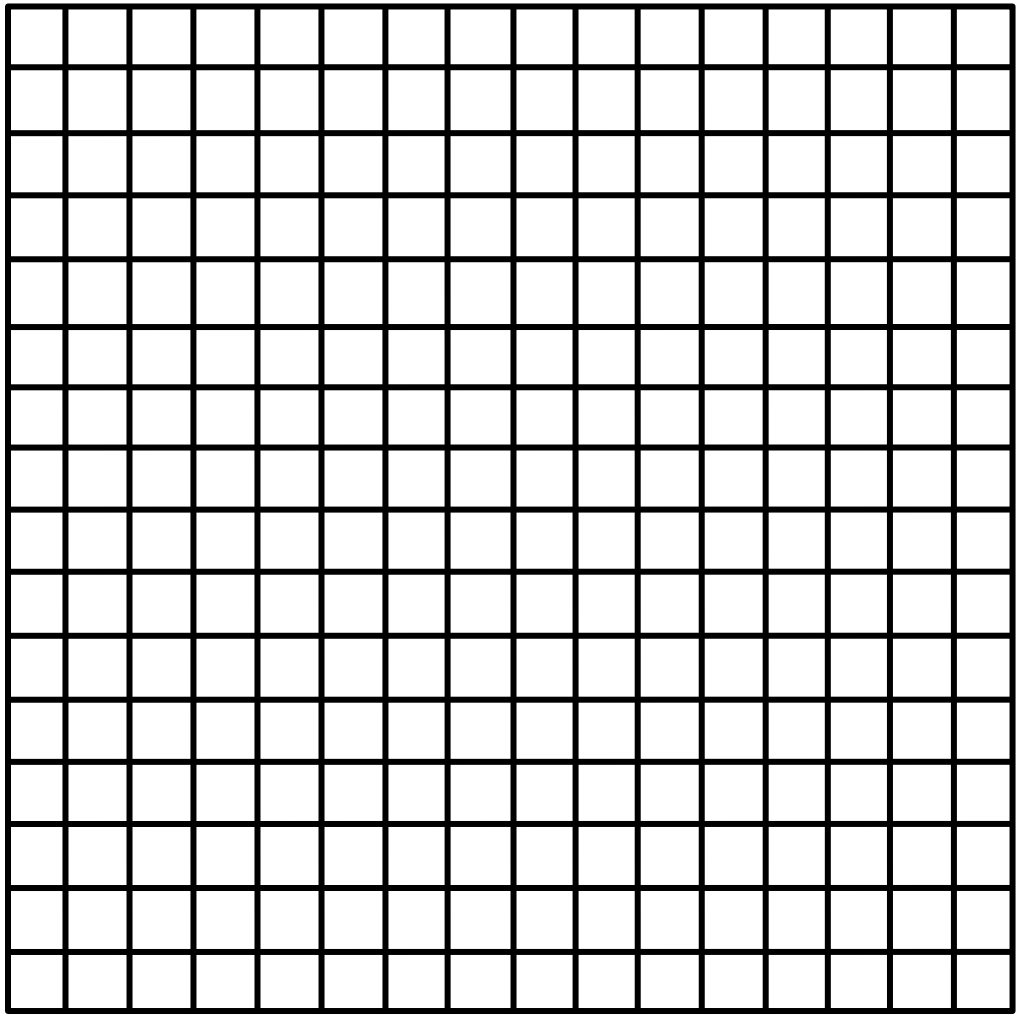

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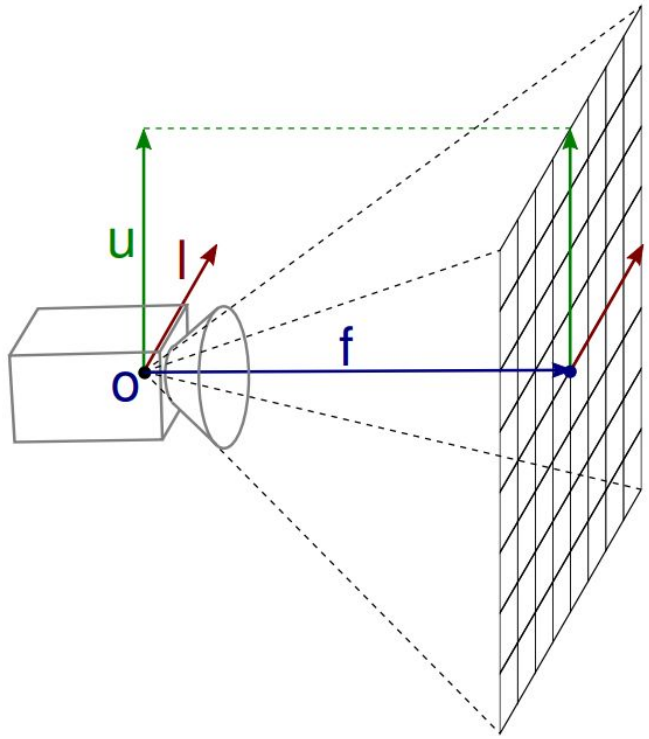

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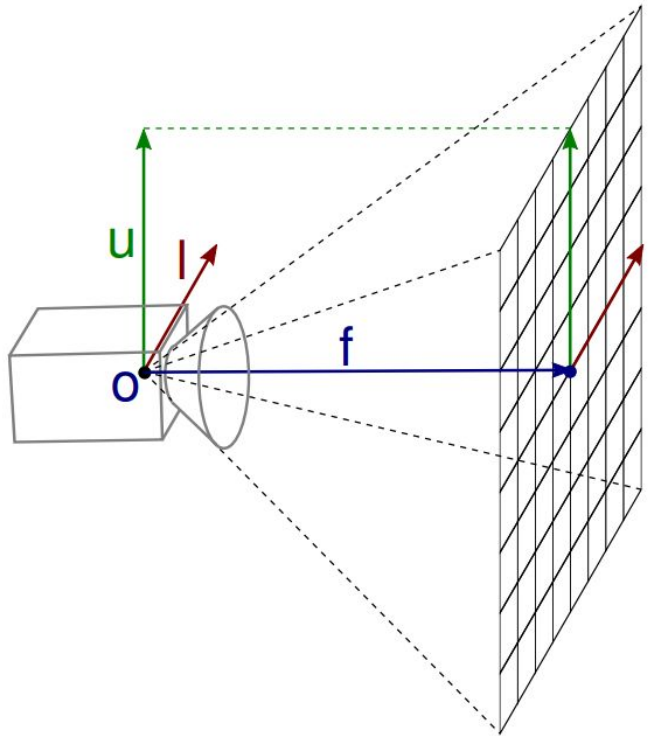

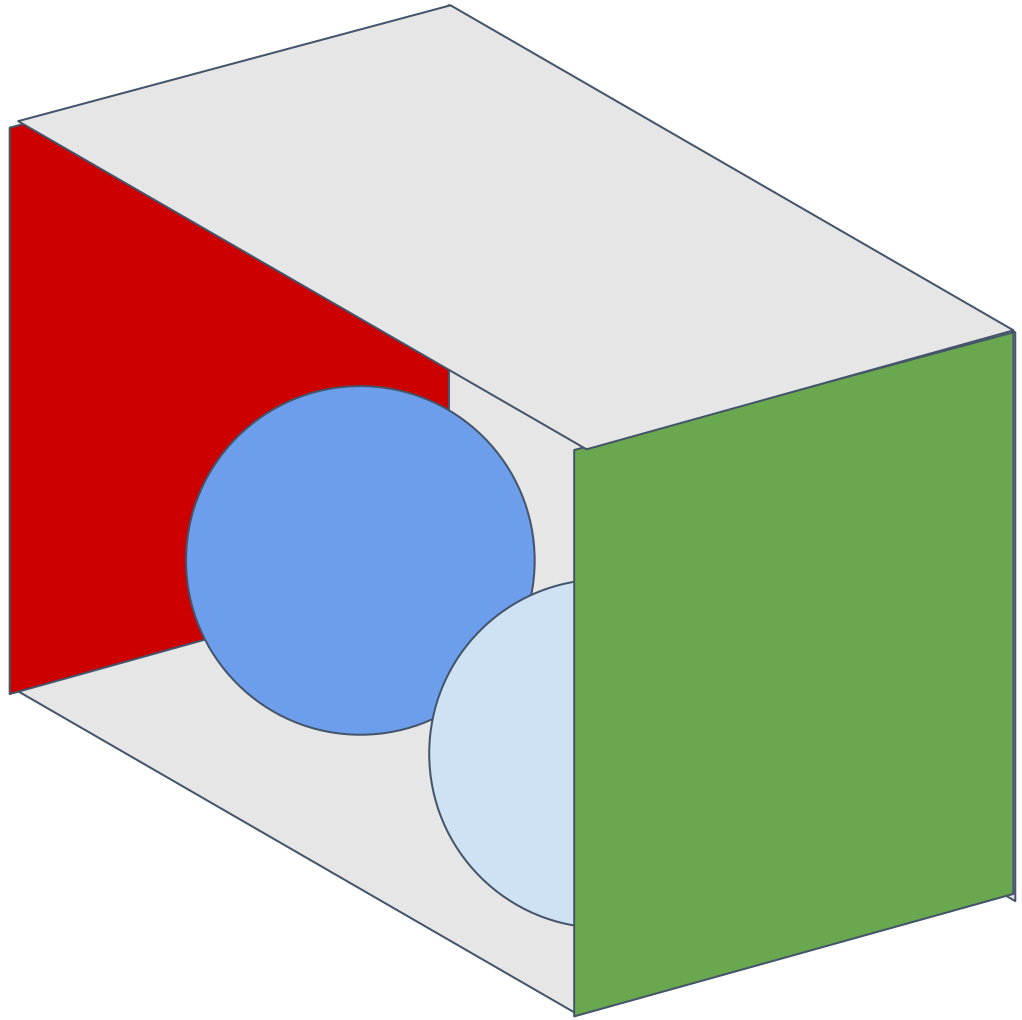

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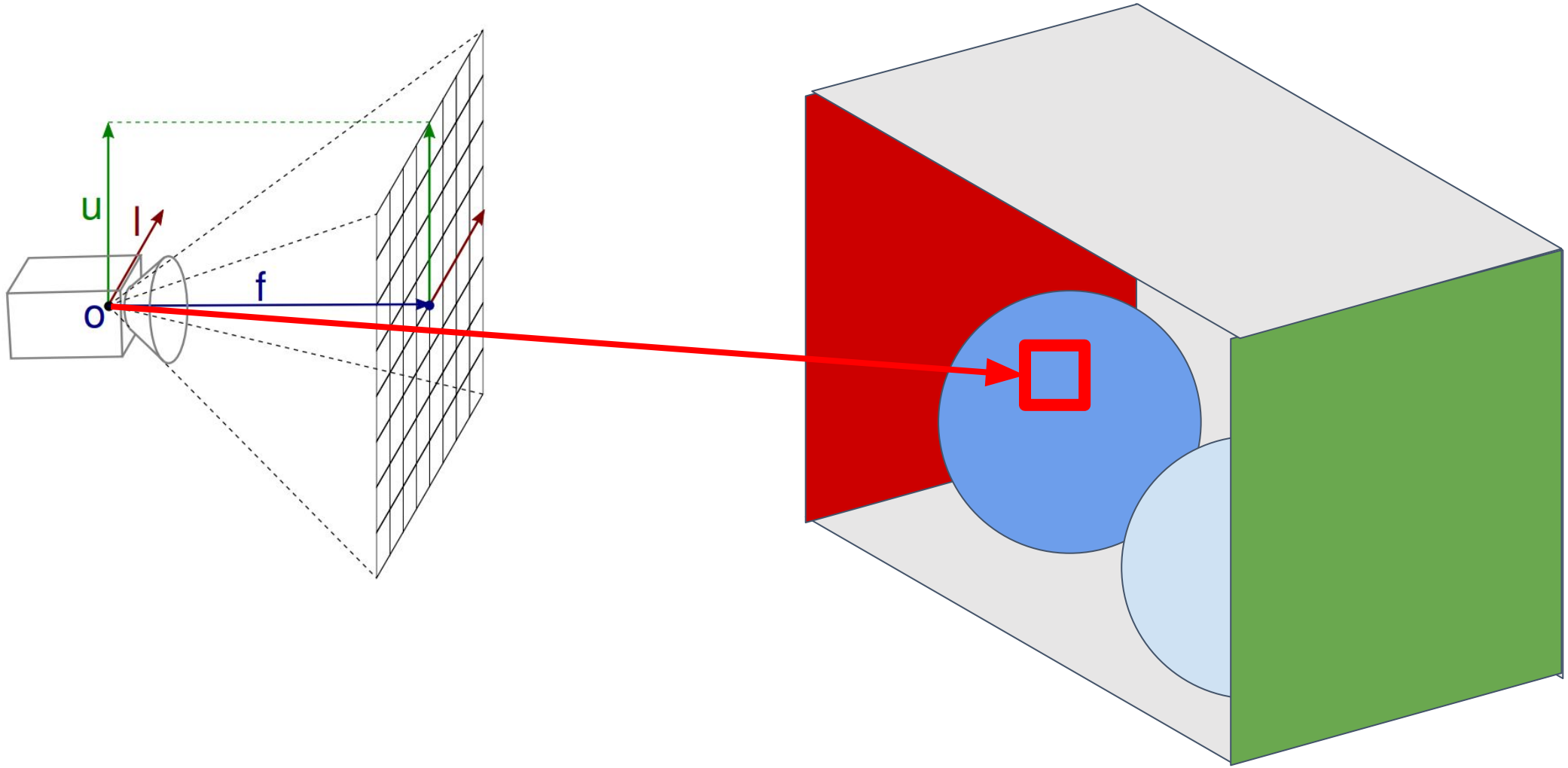

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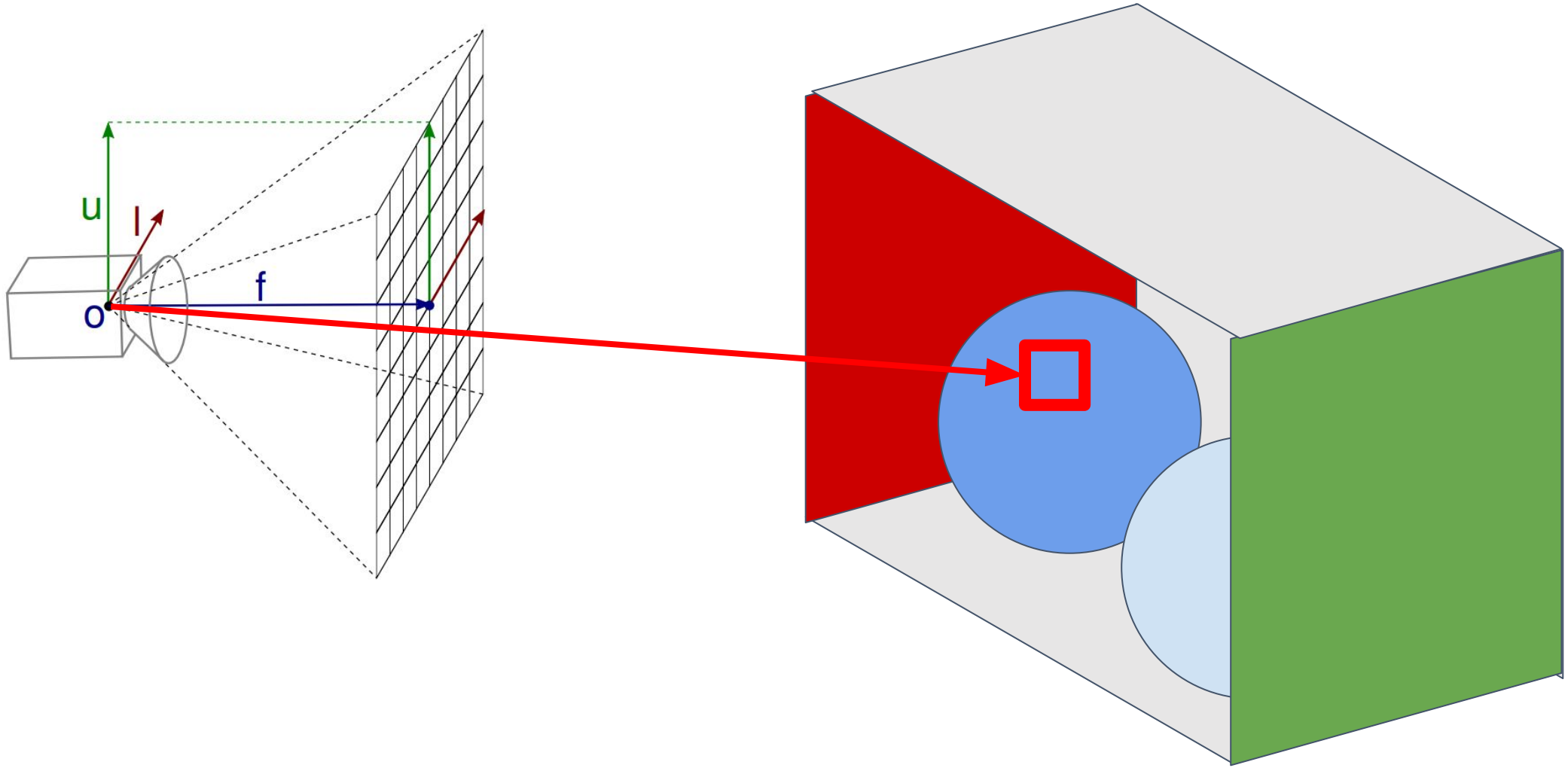
Graphics and Imaging Lab

- Let's simplify



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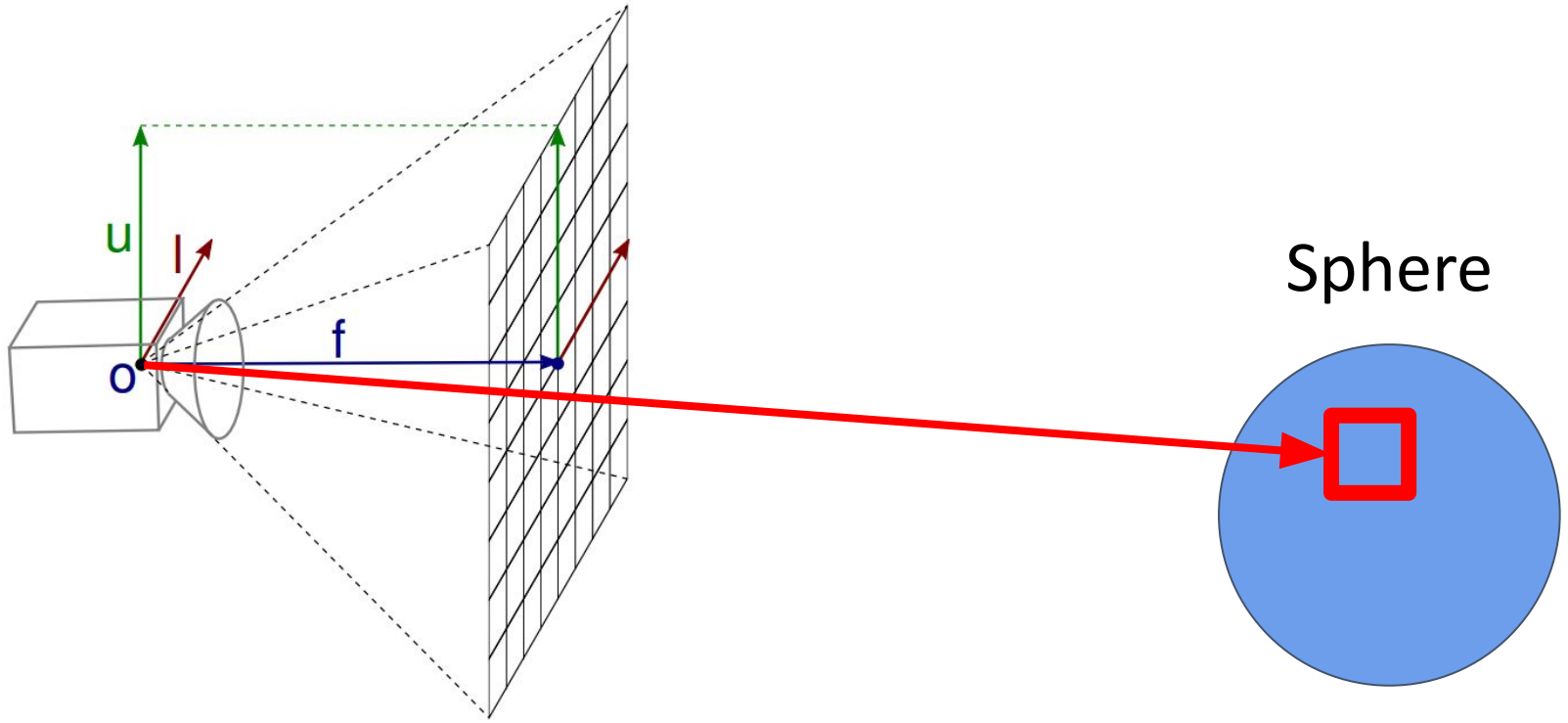

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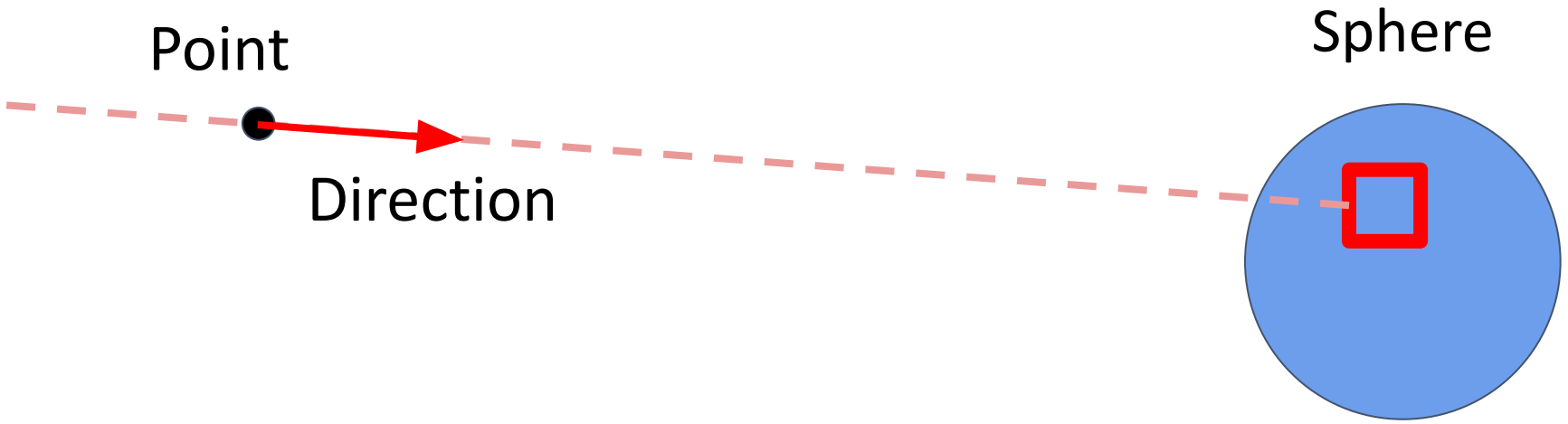
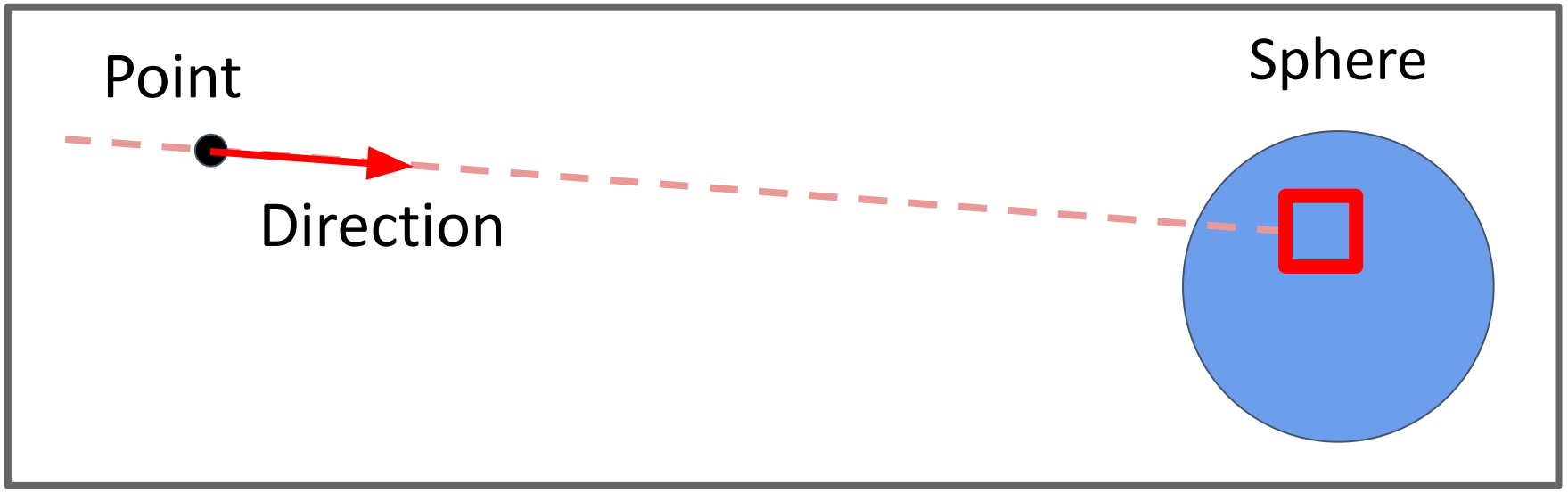


Ray intersection problem

Graphics and Imaging Lab

- This session we focus on ray intersections
- Inputs: ray (origin + direction), geometry (spheres or planes)



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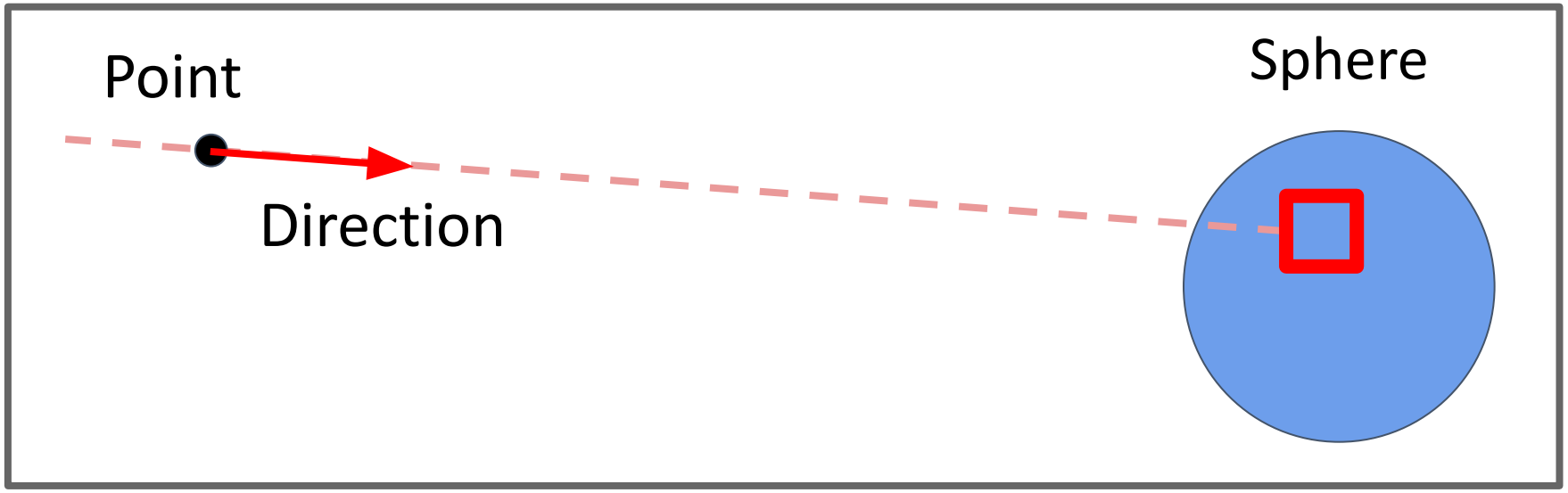
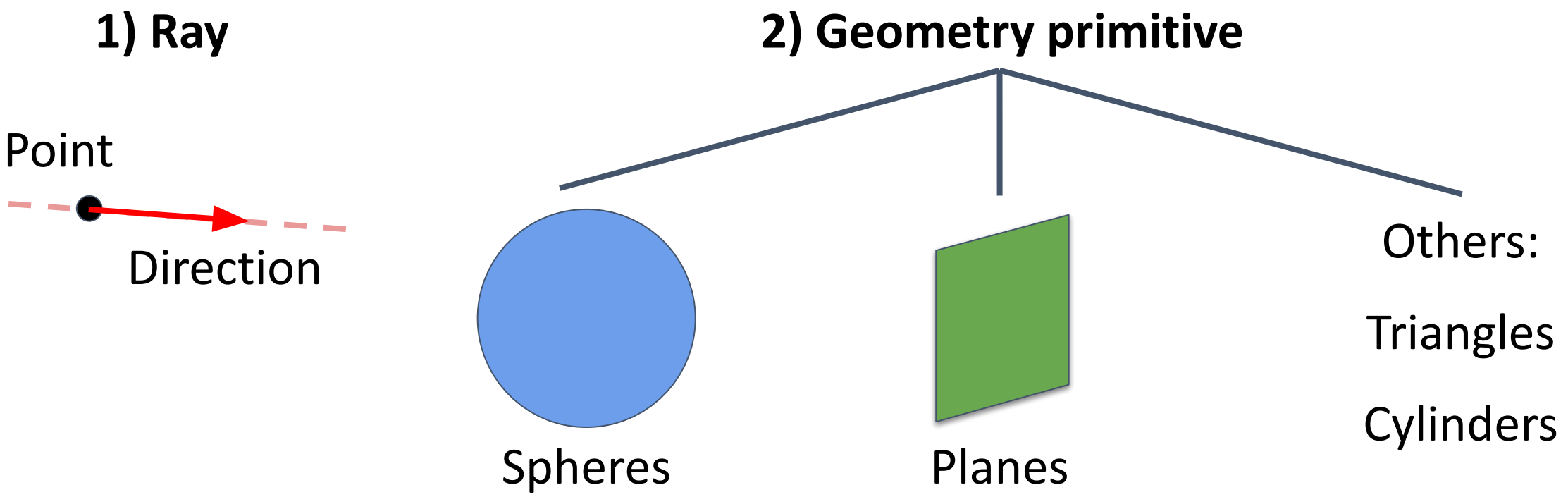


- Output: does the ray intersect? if yes, where?
  - Additional information: travel distance, surface normal, etc.

Inputs

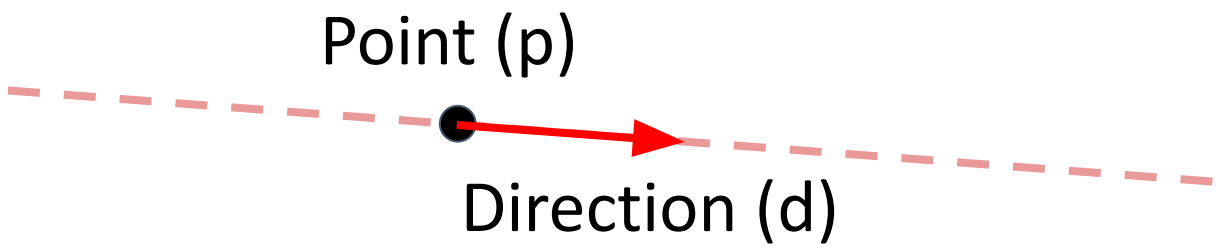
- Your intersection function should have at least two inputs:



Inputs

Graphics and Imaging Lab

- How to define a ray:



- The line - - - - is defined by
  - $p + d \cdot t$
  - $t \in \mathbb{R}$

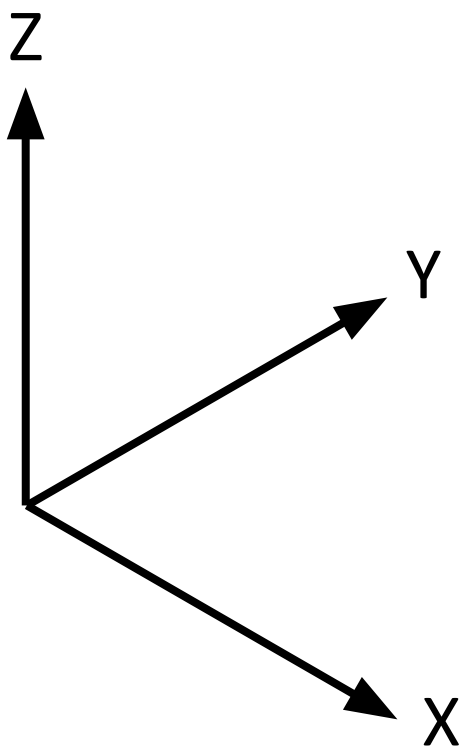
Inputs

Graphics and Imaging Lab

- How to define a geometric primitive:
  - Implicit equation

Inputs

- How to define a geometric primitive:
  - Implicit equation f(x, y, z)



- The surface of the geometry is defined by all points (x, y, z) such that f(x, y, z) = 0

Inputs

Graphics and Imaging Lab

- How to define a geometric primitive:
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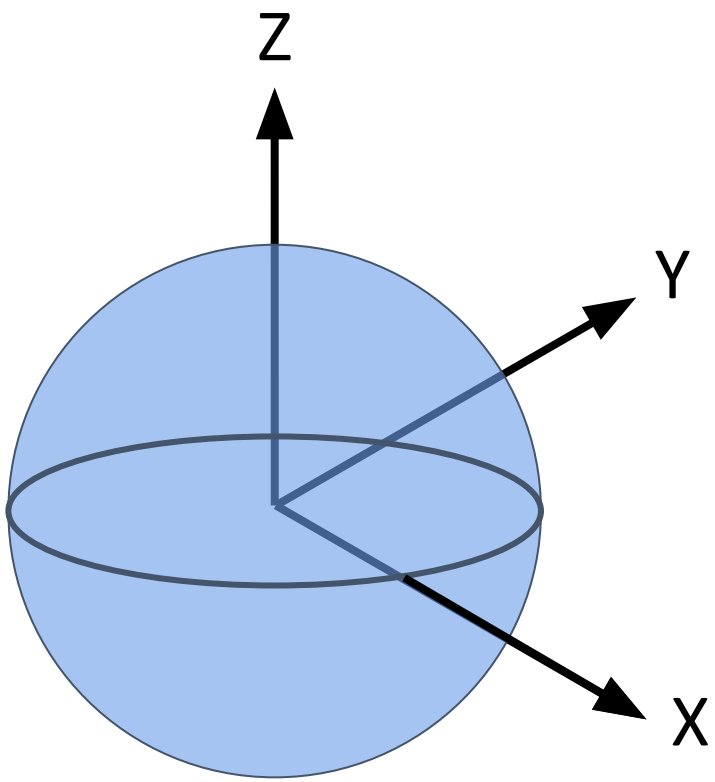

- The surface of the geometry is defined by all points (x, y, z) such that f(x, y, z) = 0
- Sphere:
  - Defined by center (c_x, c_y, c_z) and radius (r)
  - $f(x, y, z) = (x - c_x)^2 + (y - c_y)^2 + (z - c_z)^2 - r^2$

Inputs

Graphics and Imaging Lab

- How to define a geometric primitive:
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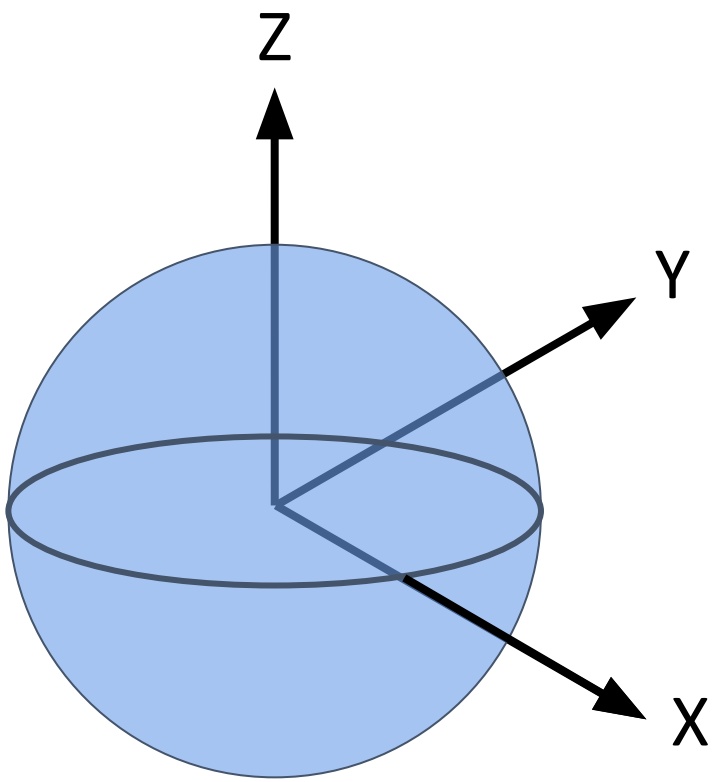

- $f(x, y, z) = (x - c_x)^2 + (y - c_y)^2 + (z - c_z)^2 - r^2$
- Points in the ray: $p + d \cdot t$

Inputs

Graphics and Imaging Lab

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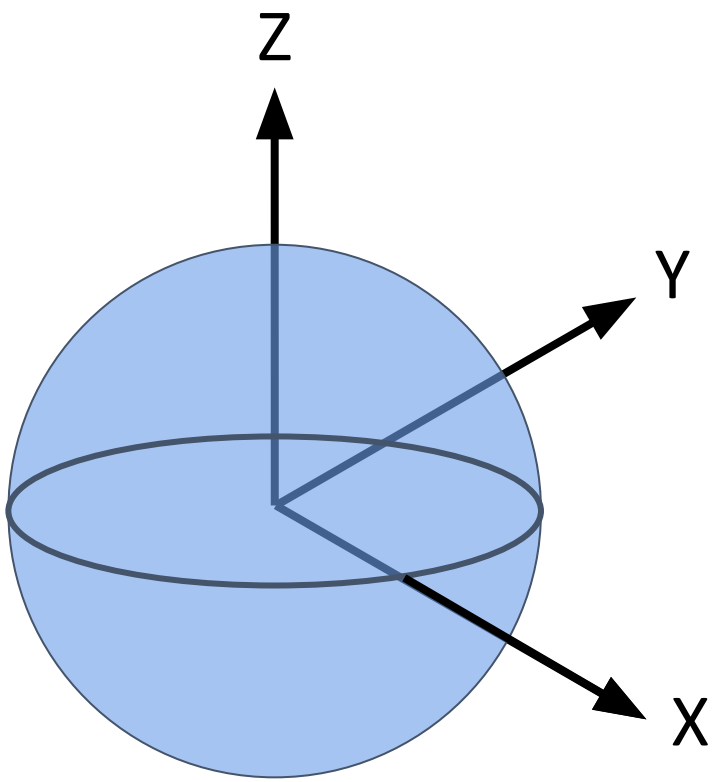
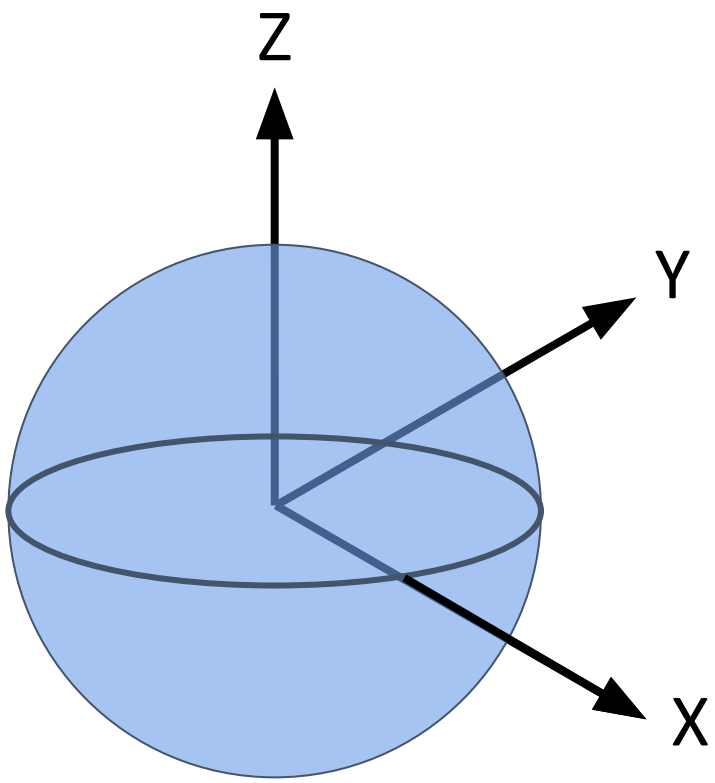


- $f(x, y, z) = (x - c_x)^2 + (y - c_y)^2 + (z - c_z)^2 - r^2$
- Points in the ray: $p + d \cdot t$
- Intersection at:
  - $f(p + d \cdot t) = 0$
  - Solve for t
  - Can have 0, 1 or 2 solutions

Inputs

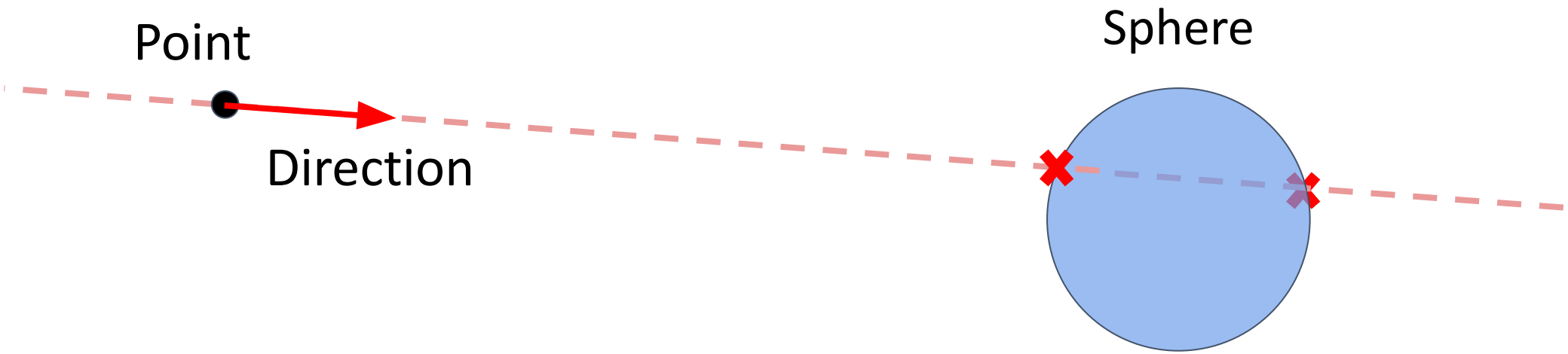
- How to define a geometric primitive:
  - Implicit equation f(x, y, z)



- $f(x, y, z) = (x - c_x)^2 + (y - c_y)^2 + (z - c_z)^2 - r^2$
- Points in the ray: $p + d \cdot t$

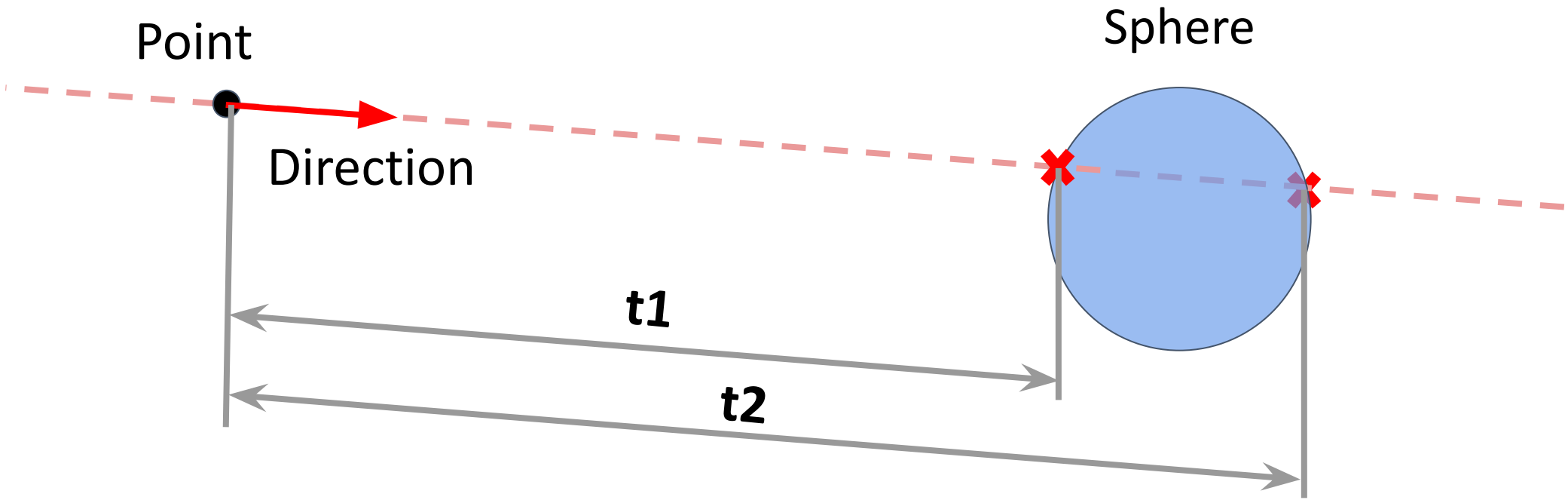
Outputs

- Solving $p + d \cdot t$ gives the distance to the sphere



Outputs

- Solving p + d · t gives the distance to the sphere



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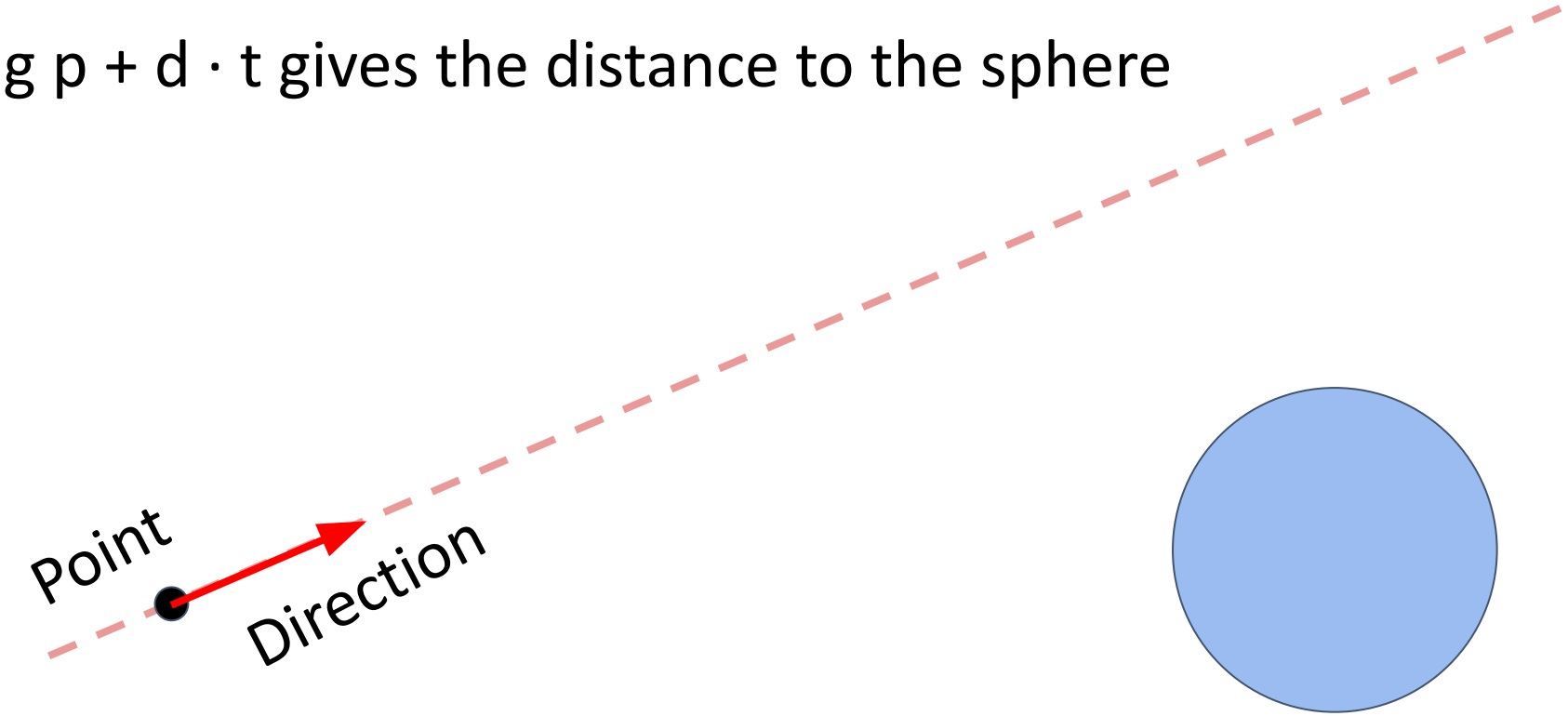

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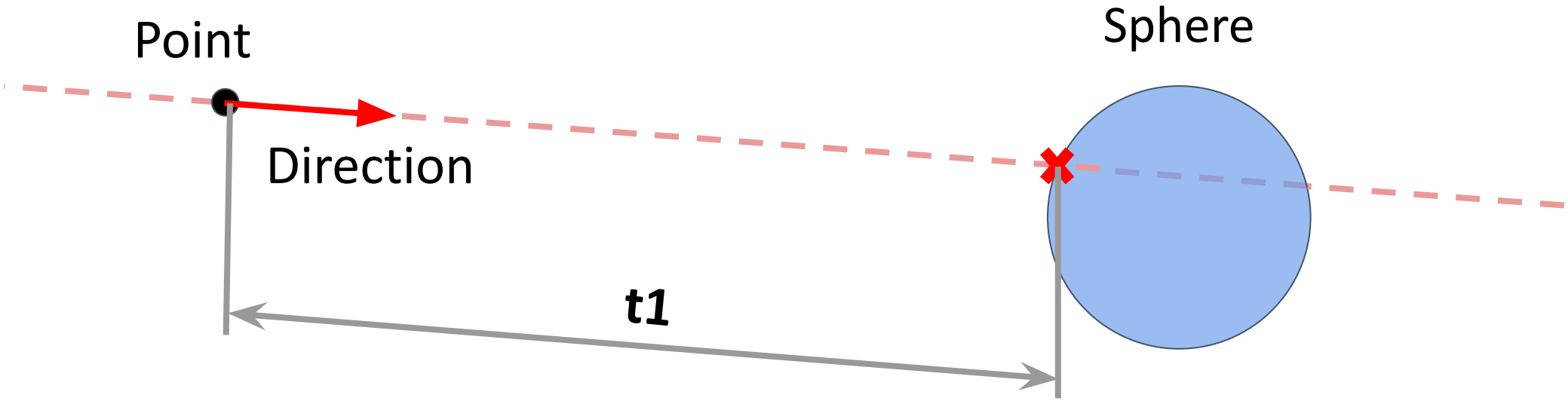

- Distance: t1
- Intersection point: p + d · t1
- Surface normal at t1, etc.

Questions

Graphics and Imaging Lab

DO ASK questions, either now or after the lab

But be reasonable, please :)

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What to expect from this session

Graphics and Imaging Lab

In the programming language of your choice, implement:

- **Primitives:** spheres and planes
- **Ray:** point + direction + other stuff you may want
- One **intersect function** per type of primitive
  - Inputs: Ray, one primitive
  - Output: Does the ray intersect? If yes, where? + additional info
- Recommended deadline: **October 18th**.
  - **Next lab:** define a camera and generate an image
  - **Extensions** (do not count towards deadline):
    - Other primitives: cones, cylinders, ellipsoids, disks or triangles
    - Acceleration structures: bounding volumes, multi-threading, etc.
    - Constructive solid geometry: google it or ask us :)