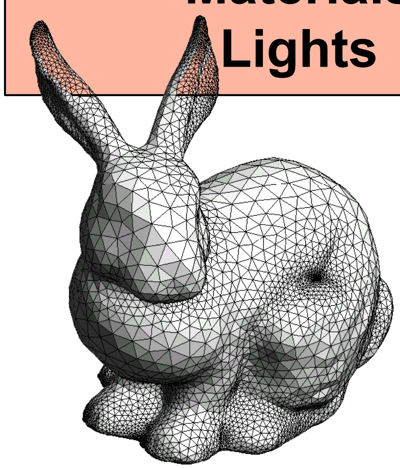
Rendering

Scene Description

3D objects
Coordinate Frame
Camera(s)
Materials
Lights



?

→

2D Image

OpenGL Rendering Pipeline

(with some details abstracted away)

Thus far…

- triangles
- vertices: $v=[x\ y\ z]^T$ local coords, on GPU
- vertex shader: $v' = M v$ to image coords
- fragment shader: colour = (1,0,0)
  colour = N•L
- instancing: redraw with $M_1, M_2, M_3, \ldots$
- many coordinate frames:
  e.g., wheel → car → world → camera → image

Algorithm: "Projective Rendering"

```
for each frame
   clear screen
   for each object instance
        for each triangle j        // project onto image:
            transform vertices      // vertex shader
            for each pixel in j     // rasterization
                compute colour      // fragment shader
```

Linear Algebra Review

vectors

dot product

Math Review

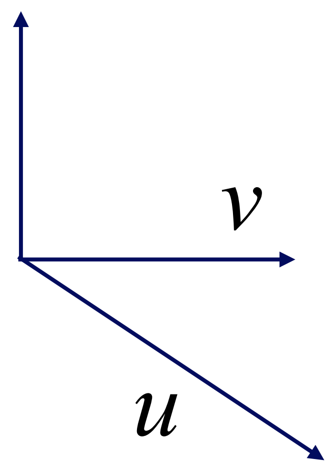
matrix-vector multiplication

(a) as dot products with the rows

(b) as weighted combinations of the columns

Math Review

Cross Product



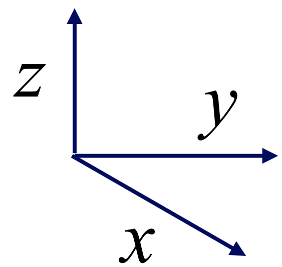
Right Handed Coordinate System

(curl fingers from u to v; thumb points to u x v)

Math Review

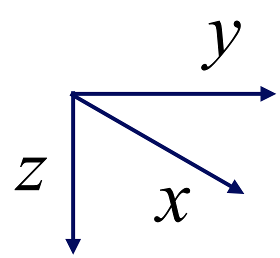
Coordinate Systems

Right-handed Coordinate System



using right-hand rule

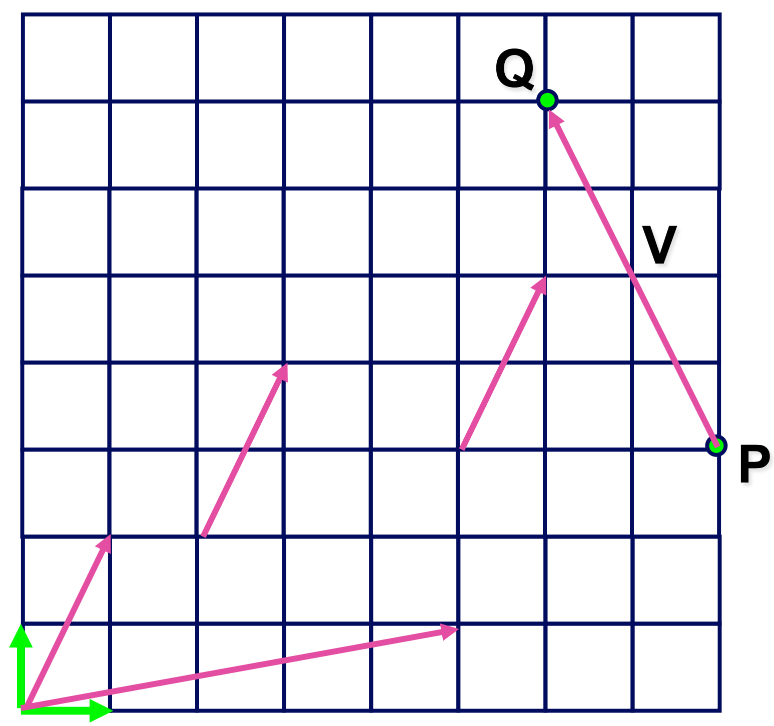
Left-handed Coordinate System



using left-hand rule

Math Review

Points and Vectors



vector space

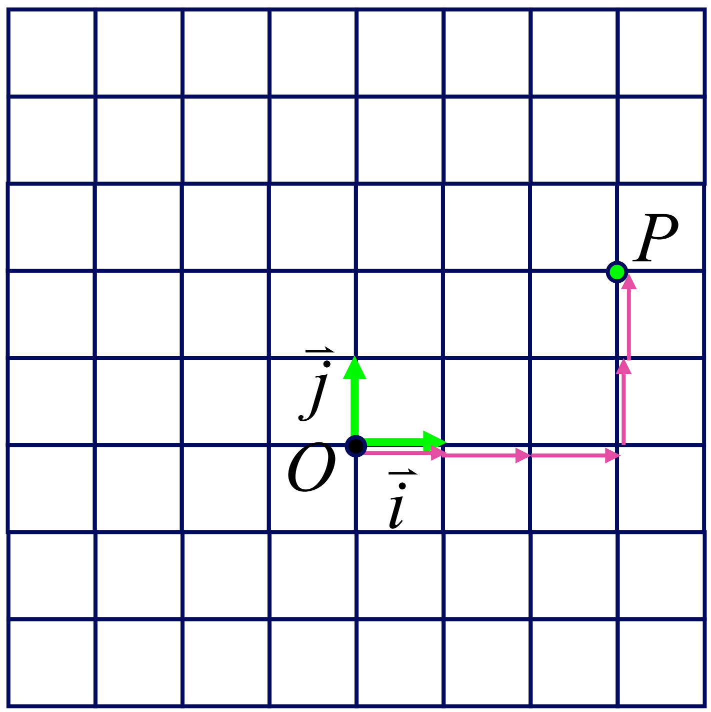
vectors are invariant under translation

affine space:

allows vector-to-point addition

Math Review

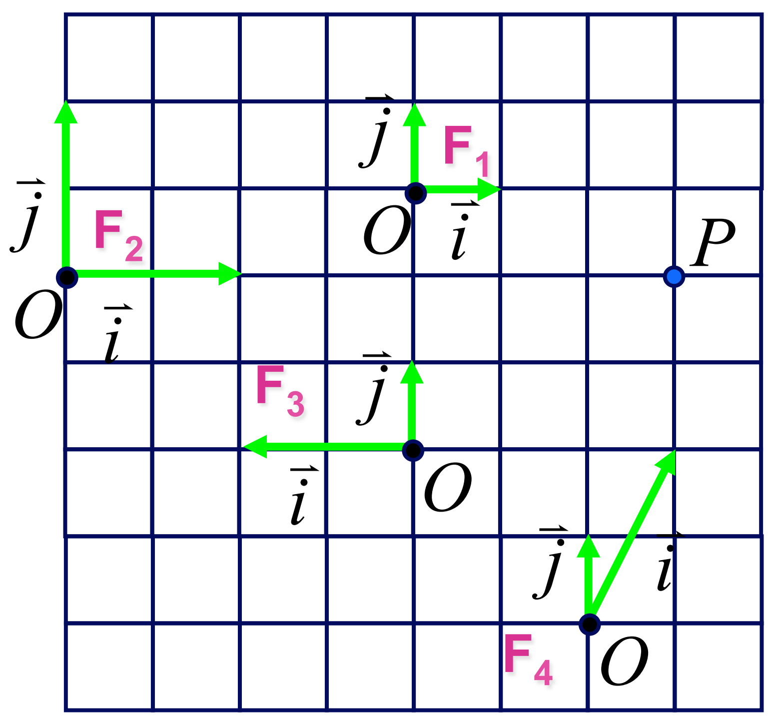
Coordinate System vs Frame



coordinate system:
frame:

Math Review

Working with Frames



$$P = O + x\vec{i} + y\vec{j}$$

F_1

F_2

F_3

F_4

Many Coordinate Frames in a Scene

(and using transformation matrices to move between them)