# 3 - Matrices and Transformations

graphics is fun; graphics requires matrix math;

thus, matrix math must be fun

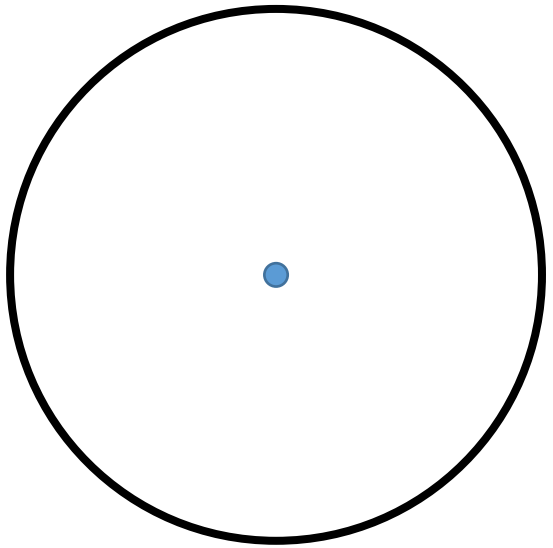
# Readings

- Review **Math** (chapter 2) as needed
- **Matrices**: 5.2
- **Transformations**:
  - 6.0-6.1.5 (simple linear 2d transforms)
  - 6.2.0 (simple linear 3d transforms)
  - 6.3-6.5 (affine transformation, inverses of transformations, coordinate transformations)

# Simple Trig: Angles

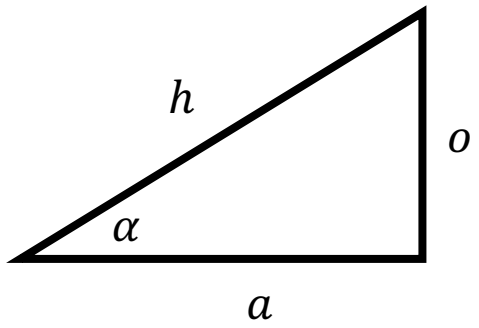
d
r
$2\pi$

circumference
radians
degrees



# Simple Trig: Angles

$$a^2 + o^2 = h^2$$

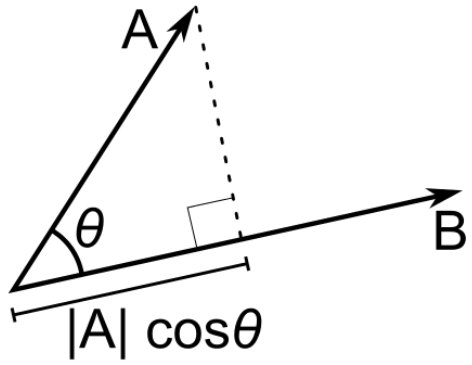



sin, cos, tan,
asin, acos, atan

# 2D Vectors

# Dot Product

$$\mathbf{A} \cdot \mathbf{B} = \|\mathbf{A}\| \, \|\mathbf{B}\| \cos\theta,$$

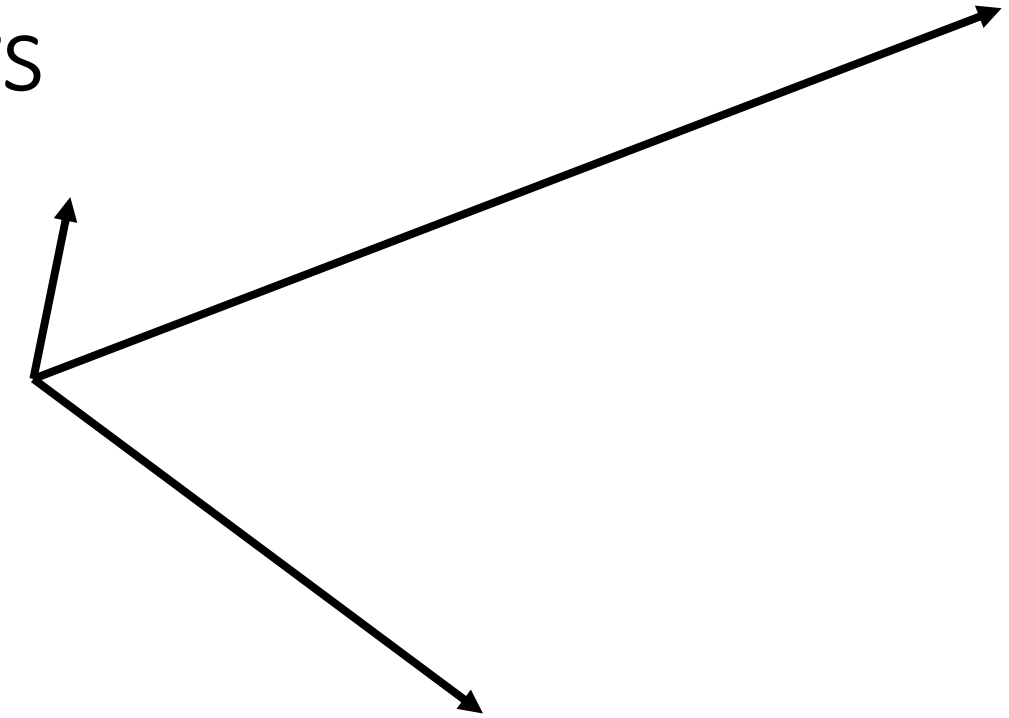





Some images from https://en.wikipedia.org/wiki/Dot_product

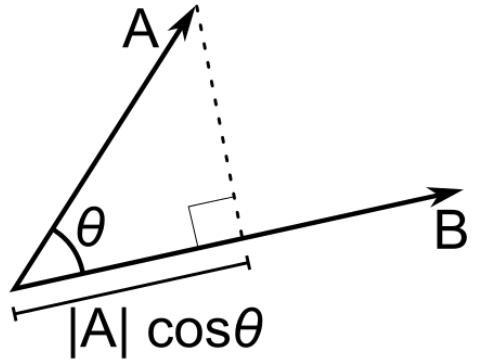
$$[2\ 1]\begin{bmatrix}-2\\4\end{bmatrix}$$

# Vectors



add/sub
length
scalar mult

# 3-D Vectors




$$\mathbf{A} \cdot \mathbf{B} = \|\mathbf{A}\| \, \|\mathbf{B}\| \cos\theta,$$

Have length and direction

$$\mathbf{V} = [x_v, y_v, z_v]$$

Length is given by the Euclidean Norm

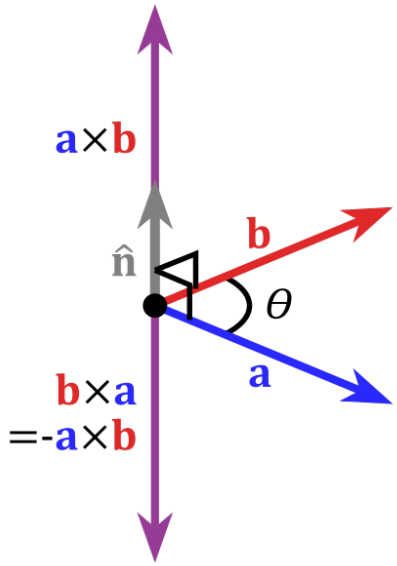
$$||V|| = \sqrt{( x_v^2 + y_v^2 + z_v^2 )}$$

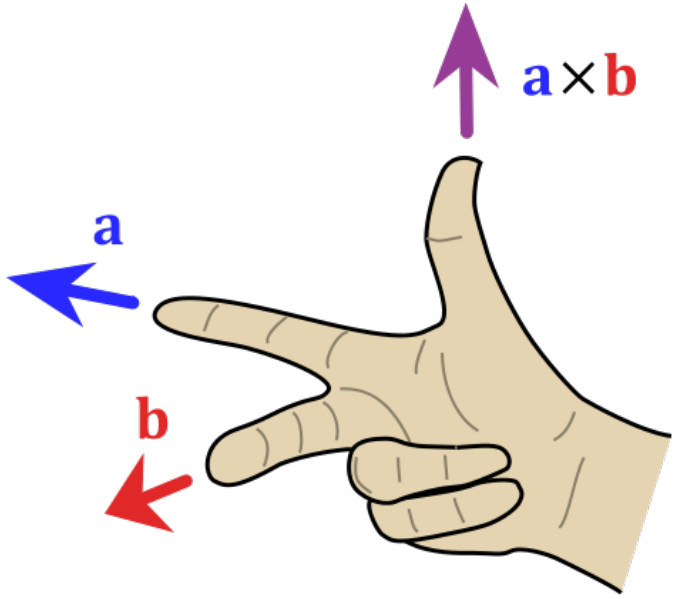
Dot Product $\mathbf{V \bullet U} = [x_v,y_v,z_v] \bullet [x_u,y_u,z_u]$

$$= x_v x_u + y_v y_u + z_v z_u$$

$$= ||V|| \, ||U|| \cos ß$$

# Cross Product



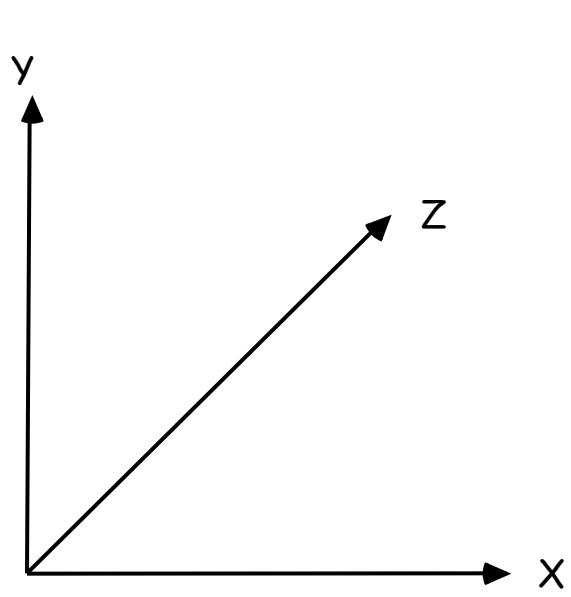

**V x U = [$v_y u_z - v_z u_y$, $-v_x u_z + v_z u_x$, $v_x u_y - v_y u_x$]**

**V x U = - (U x V)**

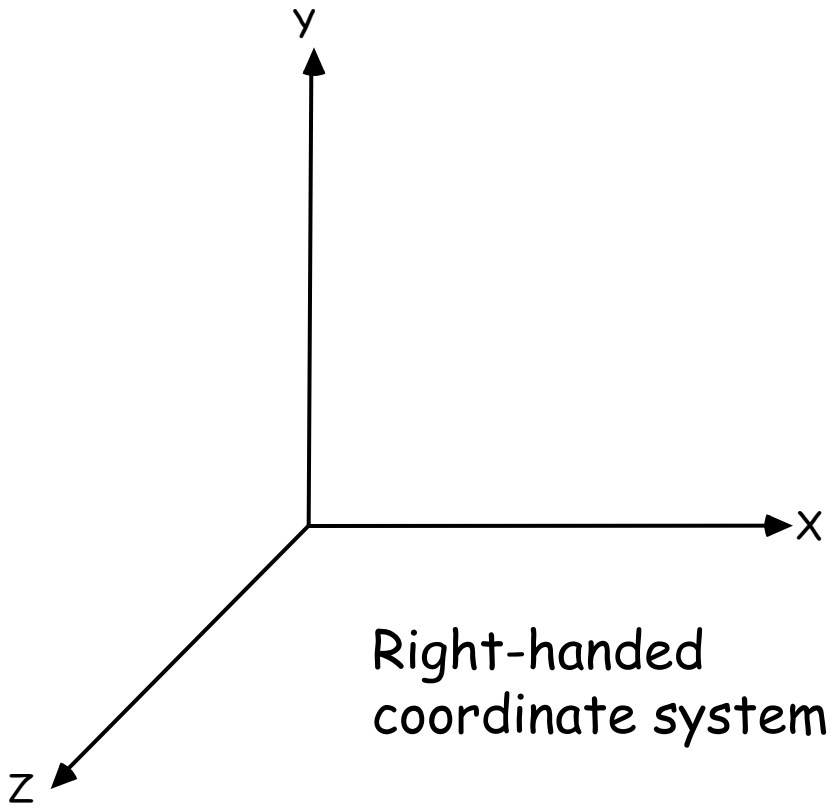


Some images from https://en.wikipedia.org/wiki/Cross_product

# 3D Coordinate Systems




Left-handed
coordinate system




Right-handed
coordinate system

# Matrices: Representation, Operations

Mult is not commutative
Identity
Inverses

# Vector Operations with Matrices

# Matrices as Transformations on Vectors

# Translation: Change Position

# Scale: Change Size

# Rotation: Change Orientation

# Homogeneous Coordinates

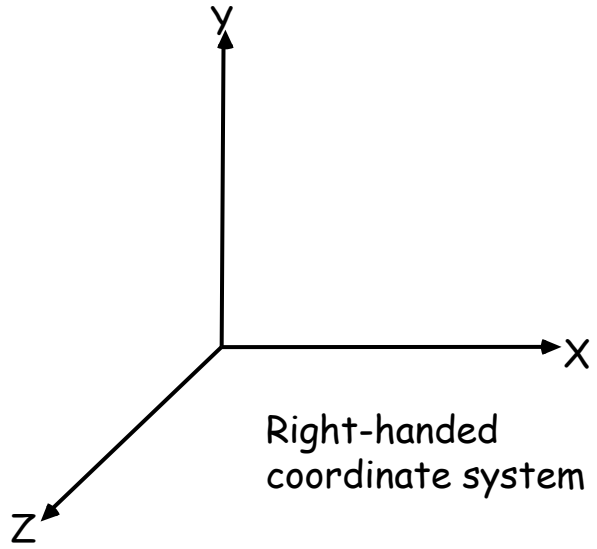
# Shear

# Reflection

# Composition of Transformations

# Commute?

# 3D Transformations



# Graphics Libraries



https://eytanmanor.medium.com/the-story-of-webgpu-the-successor-to-webgl-bf5f74bc036a