vector multiplication

Two principal ways of multiplying vectors:

1. **Dot products** (a.k.a. scalar products)

   $$d = \vec{a} \cdot \vec{b}$$

   generates a scalar value from the product of two vectors

2. Cross products

   $$\vec{c} = \vec{a} \times \vec{b}$$

   The cross product generates a vector from the product of two vectors

dot product

The dot product is key for calculating vector projections, vector decompositions, and determining orthogonality

The dot product of two vectors $\vec{a}$ and $\vec{b}$ is

$$\vec{a} \cdot \vec{b} = \sum_{i=1}^{n} a_1 b_1 + a_2 b_2 + \cdots + a_n b_n$$

The angle θ of between two vectors is determined by the formula

$$\vec{a} \cdot \vec{b} = \|\vec{a}\| \, \|\vec{b}\| \cos\theta$$

where $\|\vec{a}\|$ is the length or norm or magnitude of a vector. Thus

$$\cos\theta = \frac{\vec{a} \cdot \vec{b}}{\|\vec{a}\| \, \|\vec{b}\|} = \frac{\vec{a}}{\|\vec{a}\|} \cdot \frac{\vec{b}}{\|\vec{b}\|}$$