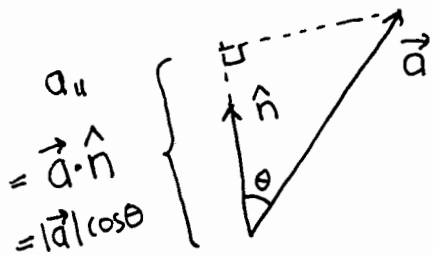


vector products and length, area, volume  
and tests for orthogonality, independence

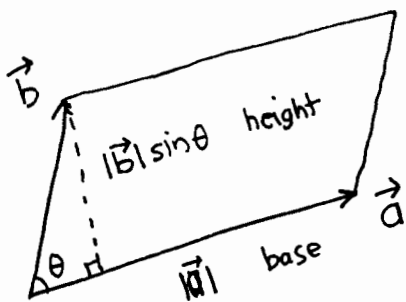
dot product: (signed=oriented) length



$$\text{length} = |\vec{a}| \cos \theta = |\vec{a} \cdot \hat{n}|$$

if zero, then orthogonal

cross-product: (oriented) area

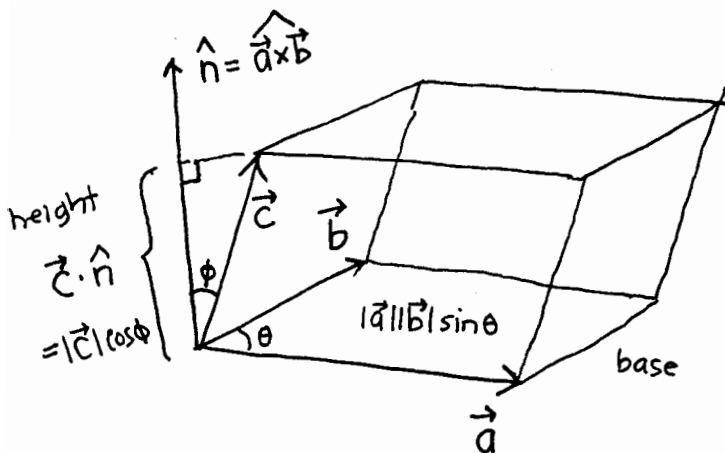


$$\text{area} = |\vec{a}| |\vec{b}| \sin \theta = |\vec{a} \times \vec{b}|$$

if zero, then collinear ( $\Leftrightarrow \vec{a} \times \vec{b} = 0$ )

if nonzero, determine 2 independent directions

triple scalar product: (oriented) volume



$$= |\vec{c}| |\vec{a}| |\vec{b}| \cos \phi \sin \theta$$

$$\text{volume} = |\vec{c}| |\cos \phi| |\vec{a} \times \vec{b}|$$

$$= |\vec{c} \cdot (\vec{a} \times \vec{b})|$$

if zero, then coplanar

if nonzero, then determine 3 independent directions

cross-product: length

