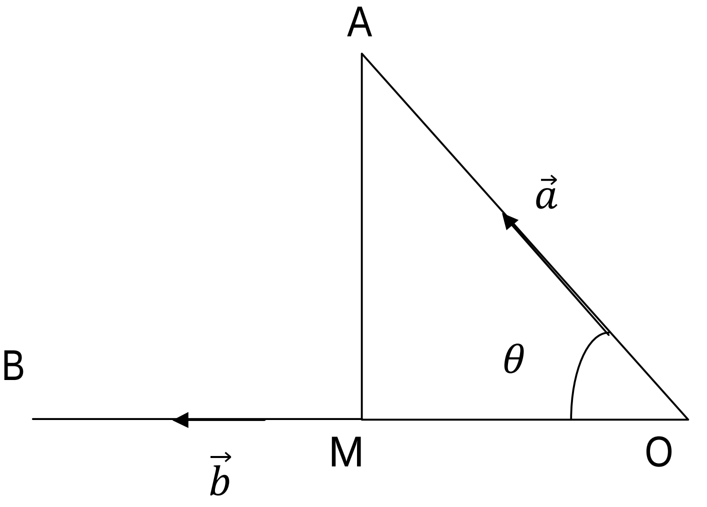
(viii) $If\ \vec{a}\ and\ \vec{b}\ are\ orthogonal\ vectors, we\ have\ \theta = \frac{\pi}{2};\ \vec{a}.\vec{b} = ab\cos\theta = 0.$

(9) **Projection**



$Let\ \overrightarrow{OA} = \vec{a}, \overrightarrow{OB} = \vec{b}\ and\ \angle BOA = \theta; also\ AM \perp OB.$

$Then, OM\ is\ the\ projection\ of\ \vec{a}\ on\ \vec{b}.$

$$OM = OAcos\theta = |\vec{a}|cos\theta = \frac{\vec{a}.\vec{b}}{|\vec{b}|}.$$

(10) **Condition of Perpendicularity**

$Let\ \vec{a} = a_1\hat{\imath} + a_2\hat{\jmath} + a_3\hat{k}\ and\ \vec{b} = b_1\hat{\imath} + b_2\hat{\jmath} + b_3\hat{k}$

$\vec{a}\ will\ be\ perpendicular\ on\ \vec{b}\ if\ \vec{a}.\vec{b} = 0 \iff a_1b_1 + a_2b_2 + a_3b_3 = 0.$

(11) **Vector product / Cross product of vectors**

$Let\ \vec{a}\ and\ \vec{b}\ be\ two\ non-zero, non-parallel\ vectors, and\ let\ \theta\ be\ the\ angle\ between$ $them\ such\ that\ 0 < \theta < \pi.$

$Then, the\ cross\ product\ of\ \vec{a}\ and\ \vec{b}\ is\ defined\ as\quad \vec{a} \times \vec{b} = (|\vec{a}||\vec{b}|sin\theta)\hat{n}$

$where\ \hat{n}\ is\ a\ unit\ vector\ perpendicular\ to\ both\ \vec{a}\ and\ \vec{b}.$

(i) $If\ \vec{a}\ and\ \vec{b}\ are\ parallel\ or\ collinear, i.e., when\ \theta = 0\ or\ \theta = \pi\ then,\ \vec{a} \times \vec{b} = \vec{0}.$

(ii) $If\ \vec{a} = \vec{0}\ or\ \vec{b} = \vec{0}, we\ define\ \vec{a} \times \vec{b} = \vec{0}.$

(iii) $For\ any\ vector\ \vec{a}, we\ have\ \vec{a} \times \vec{a} = (|\vec{a}||\vec{a}|sin0)\hat{n} = \vec{0}.$

(iv) $The\ angle\ \theta\ between\ two\ vectors\ is\ defined\ by\quad \theta = \sin^{-1}\left[\frac{|\vec{a} \times \vec{b}|}{|\vec{a}||\vec{b}|}\right].$

(v) $A\ unit\ vector\ \hat{n}\ perpendicular\ to\ each\ one\ of\ \vec{a}\ and\ \vec{b}\ is\ given\ by\ \hat{n} = \frac{(\vec{a} \times \vec{b})}{|\vec{a} \times \vec{b}|}.$

(vi) $\vec{a} \times \vec{b}.\ \vec{c} = \vec{a}.\ \vec{b} \times \vec{c}$

(vii) $\vec{b} \times \vec{a} = -(\vec{a} \times \vec{b})$

(viii) $(-\vec{b}) \times \vec{a} = (\vec{a} \times \vec{b}) = \vec{b} \times (-\vec{a})$

(12) **Area of Triangle**

$Let\ us\ consider\ \Delta ABC\ in\ which\ \overrightarrow{AB} = \vec{a}\ \&\ \overrightarrow{AC} = \vec{b}$