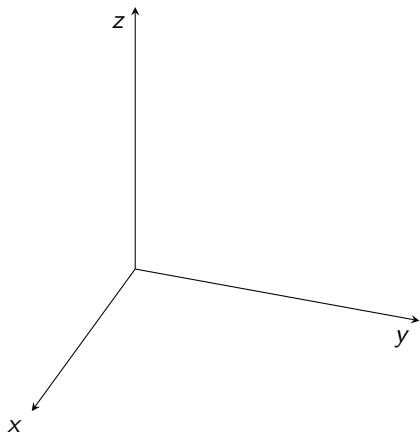


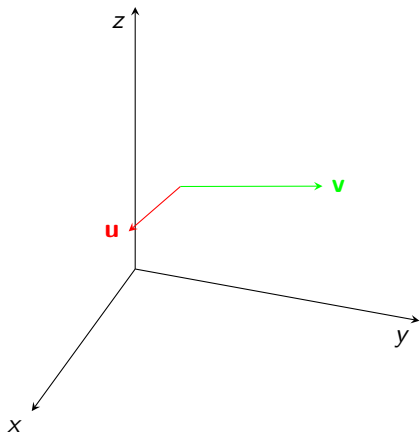
Vektorilaskenta

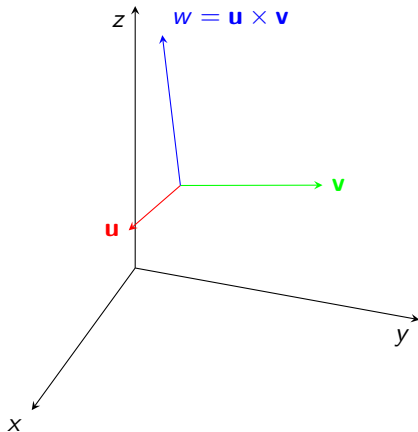
Itä-Suomen yliopisto,
verkkomateriaali

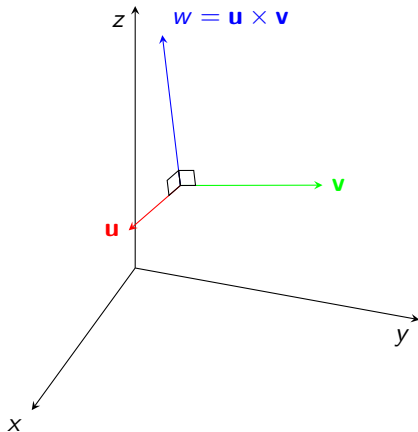


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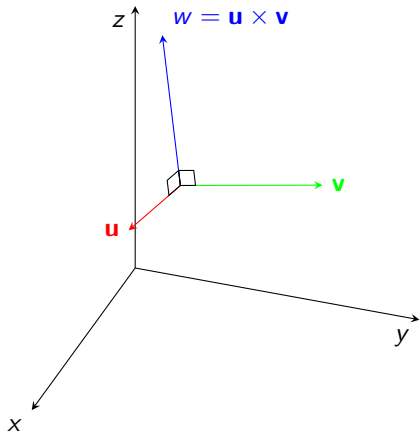






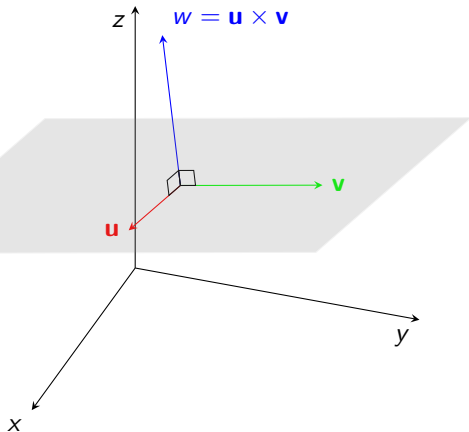
\mathbf{w} on se vektori, jolle

(i) $\mathbf{u} \cdot \mathbf{w} = 0, \quad \mathbf{v} \cdot \mathbf{w} = 0$



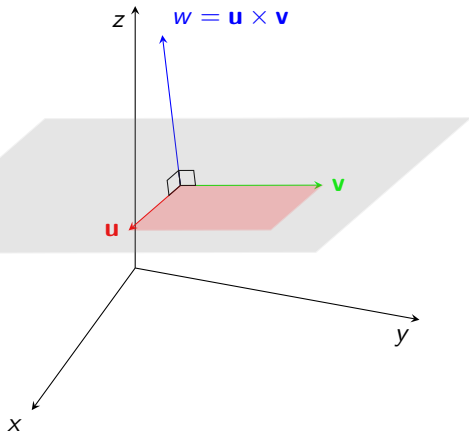
\mathbf{w} on se vektori, jolle

$$(i) \mathbf{u} \cdot \mathbf{w} = 0, \quad \mathbf{v} \cdot \mathbf{w} = 0$$



\mathbf{w} on se vektori, jolle

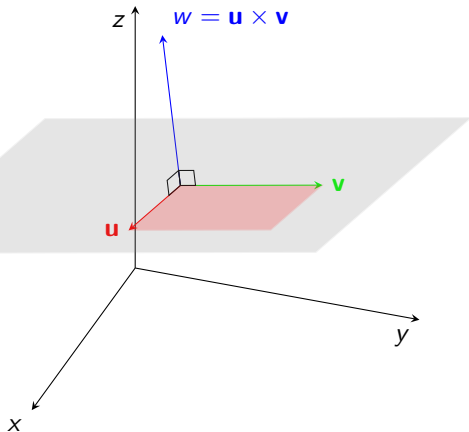
(i) $\mathbf{u} \cdot \mathbf{w} = 0$, $\mathbf{v} \cdot \mathbf{w} = 0$



\mathbf{w} on se vektori, jolle

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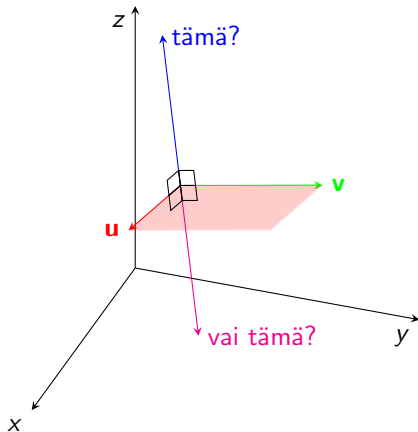
(ii) $|\mathbf{w}| = |\mathbf{u}||\mathbf{v}| \sin \theta$

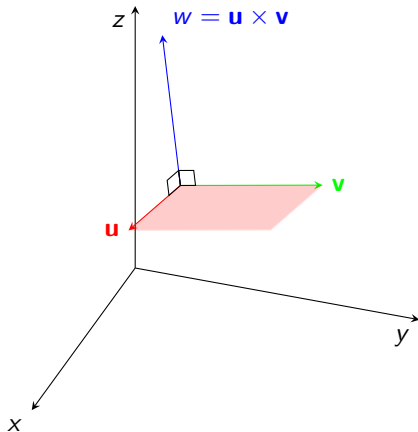


\mathbf{w} on se vektori, jolle

(i) $\mathbf{u} \cdot \mathbf{w} = 0, \quad \mathbf{v} \cdot \mathbf{w} = 0$

(ii) $|\mathbf{w}| = |\mathbf{u}||\mathbf{v}| \sin \theta$





\mathbf{w} on se vektori, jolle

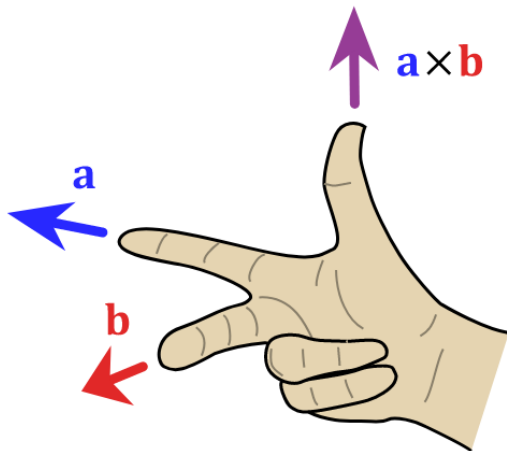
(i) $\mathbf{u} \cdot \mathbf{w} = 0, \quad \mathbf{v} \cdot \mathbf{w} = 0$

(ii) $|\mathbf{w}| = |\mathbf{u}||\mathbf{v}| \sin \theta$



(iii) $(\mathbf{u}, \mathbf{v}, \mathbf{w})$

positiivisesti suunnistettu

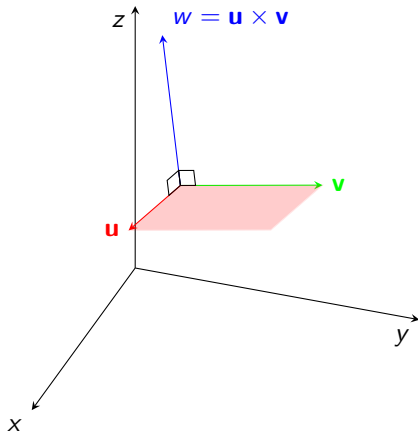
eli oikean käden systeemi



https://en.wikipedia.org/wiki/Right-hand_rule#/media/File:Right_hand_rule_cross_product.svg

 **Acdx** - Self-made, based on [Image:Right_hand_cross_product.png](#)  CC BY-SA 3.0



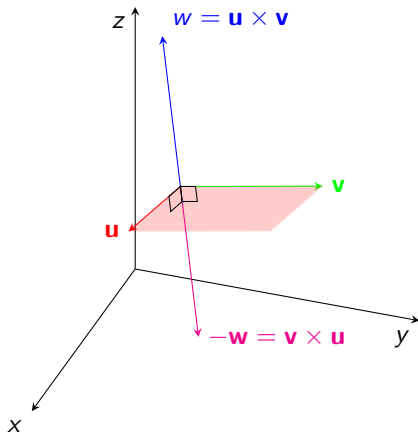


\mathbf{w} on se vektori, jolle

(i) $\mathbf{u} \cdot \mathbf{w} = 0, \quad \mathbf{v} \cdot \mathbf{w} = 0$

(ii) $|\mathbf{w}| = |\mathbf{u}||\mathbf{v}| \sin \theta$

(iii) $(\mathbf{u}, \mathbf{v}, \mathbf{w})$ pos.suun.

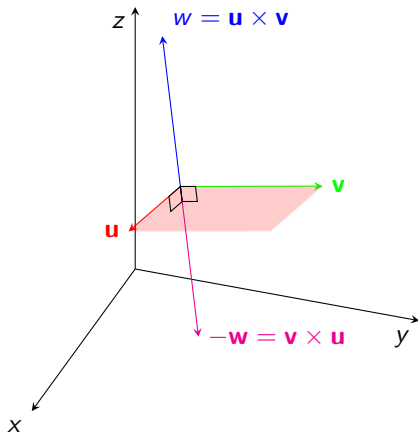


\mathbf{w} on se vektori, jolle

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(iii) $(\mathbf{u}, \mathbf{v}, \mathbf{w})$ pos.suun.



\mathbf{w} on se vektori, jolle

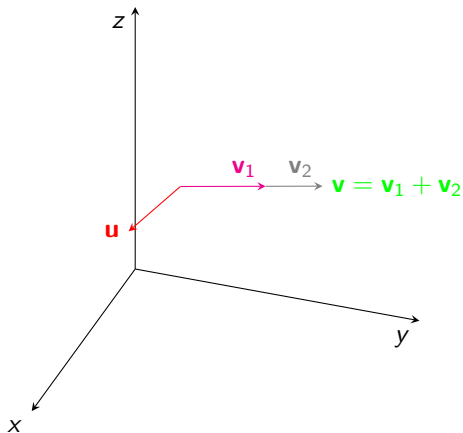
(i) $\mathbf{u} \cdot \mathbf{w} = 0, \quad \mathbf{v} \cdot \mathbf{w} = 0$

(ii) $|\mathbf{w}| = |\mathbf{u}||\mathbf{v}| \sin \theta$

(iii) $(\mathbf{u}, \mathbf{v}, \mathbf{w})$ pos.suun.

Ominaisuuksia

$$\mathbf{v} \times \mathbf{u} = -\mathbf{u} \times \mathbf{v}$$



\mathbf{w} on se vektori, jolle

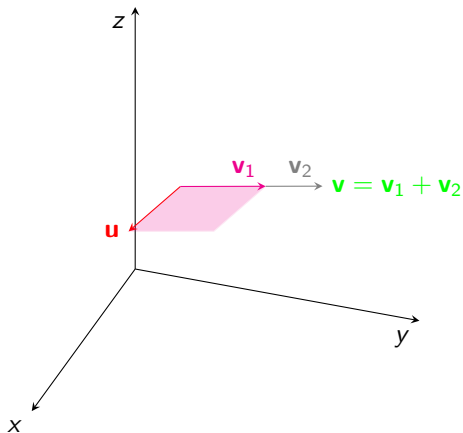
(i) $\mathbf{u} \cdot \mathbf{w} = 0, \quad \mathbf{v} \cdot \mathbf{w} = 0$

(ii) $|\mathbf{w}| = |\mathbf{u}||\mathbf{v}| \sin \theta$

(iii) $(\mathbf{u}, \mathbf{v}, \mathbf{w})$ pos.suun.

Ominaisuuksia

$$\mathbf{v} \times \mathbf{u} = -\mathbf{u} \times \mathbf{v}$$



\mathbf{w} on se vektori, jolle

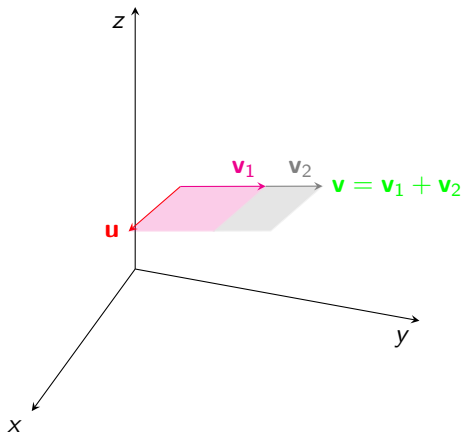
(i) $\mathbf{u} \cdot \mathbf{w} = 0, \quad \mathbf{v} \cdot \mathbf{w} = 0$

(ii) $|\mathbf{w}| = |\mathbf{u}||\mathbf{v}| \sin \theta$

(iii) $(\mathbf{u}, \mathbf{v}, \mathbf{w})$ pos.suun.

Ominaisuuksia

$$\mathbf{v} \times \mathbf{u} = -\mathbf{u} \times \mathbf{v}$$



\mathbf{w} on se vektori, jolle

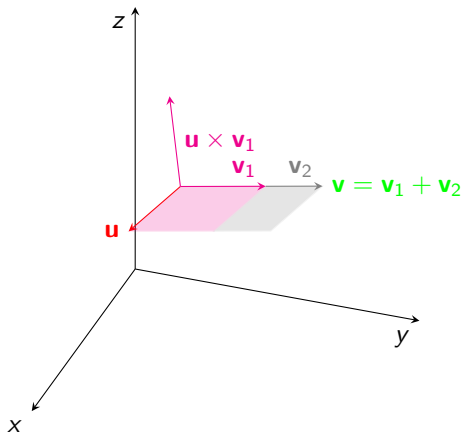
(i) $\mathbf{u} \cdot \mathbf{w} = 0, \quad \mathbf{v} \cdot \mathbf{w} = 0$

(ii) $|\mathbf{w}| = |\mathbf{u}||\mathbf{v}| \sin \theta$

(iii) $(\mathbf{u}, \mathbf{v}, \mathbf{w})$ pos.suun.

Ominaisuuksia

$$\mathbf{v} \times \mathbf{u} = -\mathbf{u} \times \mathbf{v}$$



\mathbf{w} on se vektori, jolle

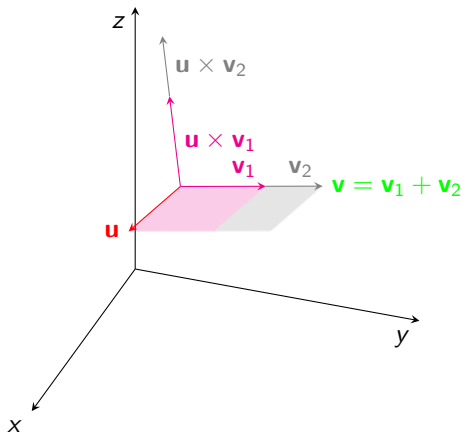
(i) $\mathbf{u} \cdot \mathbf{w} = 0, \quad \mathbf{v} \cdot \mathbf{w} = 0$

(ii) $|\mathbf{w}| = |\mathbf{u}||\mathbf{v}| \sin \theta$

(iii) $(\mathbf{u}, \mathbf{v}, \mathbf{w})$ pos.suun.

Ominaisuuksia

$$\mathbf{v} \times \mathbf{u} = -\mathbf{u} \times \mathbf{v}$$



\mathbf{w} on se vektori, jolle

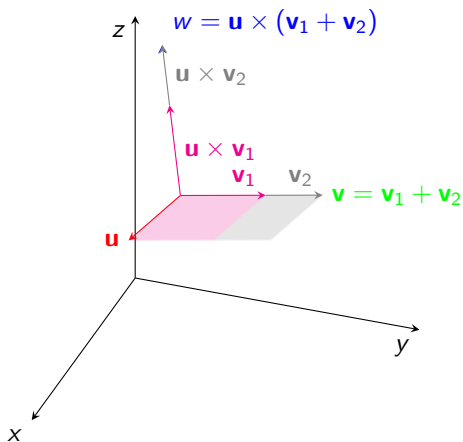
(i) $\mathbf{u} \cdot \mathbf{w} = 0, \quad \mathbf{v} \cdot \mathbf{w} = 0$

(ii) $|\mathbf{w}| = |\mathbf{u}||\mathbf{v}| \sin \theta$

(iii) $(\mathbf{u}, \mathbf{v}, \mathbf{w})$ pos.suun.

Ominaisuuksia

$$\mathbf{v} \times \mathbf{u} = -\mathbf{u} \times \mathbf{v}$$



\mathbf{w} on se vektori, jolle

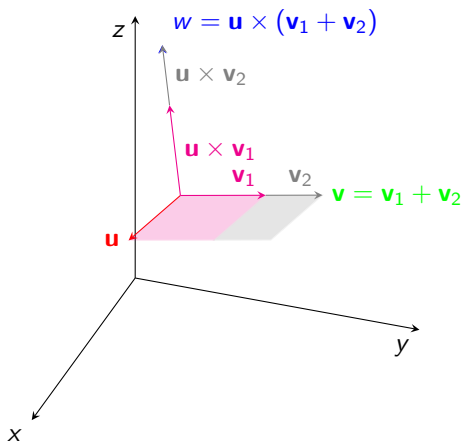
(i) $\mathbf{u} \cdot \mathbf{w} = 0, \quad \mathbf{v} \cdot \mathbf{w} = 0$

(ii) $|\mathbf{w}| = |\mathbf{u}||\mathbf{v}| \sin \theta$

(iii) $(\mathbf{u}, \mathbf{v}, \mathbf{w})$ pos.suun.

Ominaisuuksia

$\mathbf{v} \times \mathbf{u} = -\mathbf{u} \times \mathbf{v}$



\mathbf{w} on se vektori, jolle

(i) $\mathbf{u} \cdot \mathbf{w} = 0, \quad \mathbf{v} \cdot \mathbf{w} = 0$

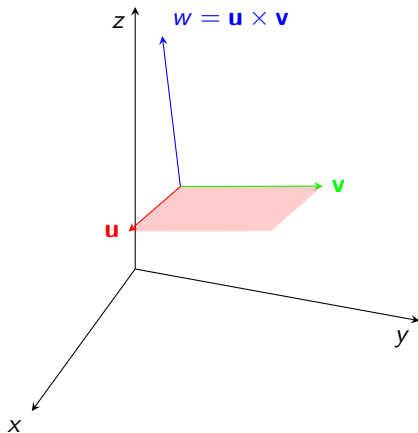
(ii) $|\mathbf{w}| = |\mathbf{u}||\mathbf{v}| \sin \theta$

(iii) $(\mathbf{u}, \mathbf{v}, \mathbf{w})$ pos.suun.

Ominaisuuksia

$$\mathbf{v} \times \mathbf{u} = -\mathbf{u} \times \mathbf{v}$$

$$\mathbf{u} \times (\mathbf{v}_1 + \mathbf{v}_2) = \mathbf{u} \times \mathbf{v}_1 + \mathbf{u} \times \mathbf{v}_2$$



\mathbf{w} on se vektori, jolle

(i) $\mathbf{u} \cdot \mathbf{w} = 0, \quad \mathbf{v} \cdot \mathbf{w} = 0$

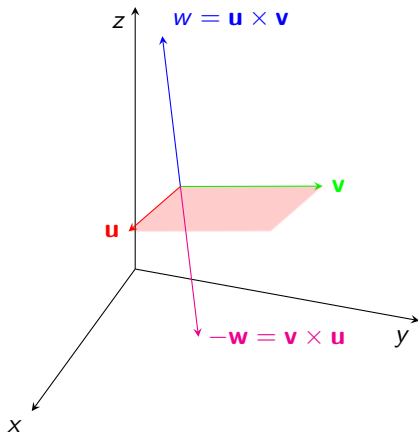
(ii) $|\mathbf{w}| = |\mathbf{u}||\mathbf{v}| \sin \theta$

(iii) $(\mathbf{u}, \mathbf{v}, \mathbf{w})$ pos.suun.

Ominaisuuksia

$$\mathbf{v} \times \mathbf{u} = -\mathbf{u} \times \mathbf{v}$$

$$\mathbf{u} \times (\mathbf{a} + \mathbf{b}) = \mathbf{u} \times \mathbf{a} + \mathbf{u} \times \mathbf{b}$$



\mathbf{w} on se vektori, jolle

(i) $\mathbf{u} \cdot \mathbf{w} = 0, \quad \mathbf{v} \cdot \mathbf{w} = 0$

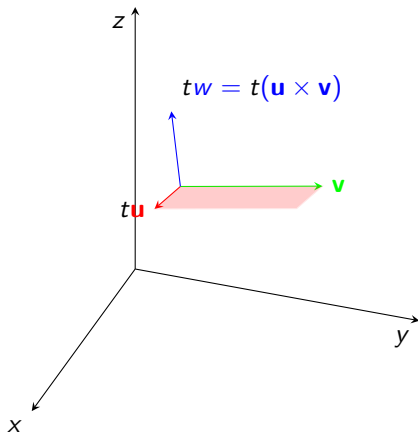
(ii) $|\mathbf{w}| = |\mathbf{u}||\mathbf{v}| \sin \theta$

(iii) $(\mathbf{u}, \mathbf{v}, \mathbf{w})$ pos.suun.

Ominaisuuksia

$$\mathbf{v} \times \mathbf{u} = -\mathbf{u} \times \mathbf{v}$$

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(ii) $|\mathbf{w}| = |\mathbf{u}||\mathbf{v}| \sin \theta$

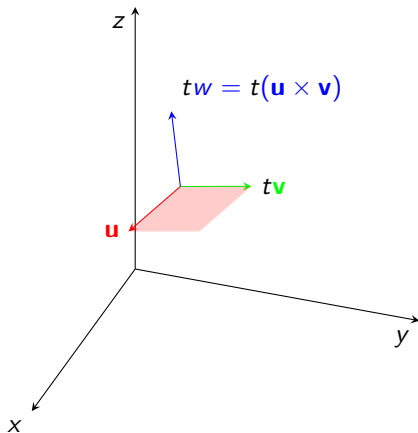
(iii) $(\mathbf{u}, \mathbf{v}, \mathbf{w})$ pos.suun.

Ominaisuuksia

$$\mathbf{v} \times \mathbf{u} = -\mathbf{u} \times \mathbf{v}$$

$$\mathbf{u} \times (\mathbf{a} + \mathbf{b}) = \mathbf{u} \times \mathbf{a} + \mathbf{u} \times \mathbf{b}$$

$$t(\mathbf{u} \times \mathbf{v}) = (t\mathbf{u}) \times \mathbf{v}$$



\mathbf{w} on se vektori, jolle

(i) $\mathbf{u} \cdot \mathbf{w} = 0, \quad \mathbf{v} \cdot \mathbf{w} = 0$

(ii) $|\mathbf{w}| = |\mathbf{u}||\mathbf{v}| \sin \theta$

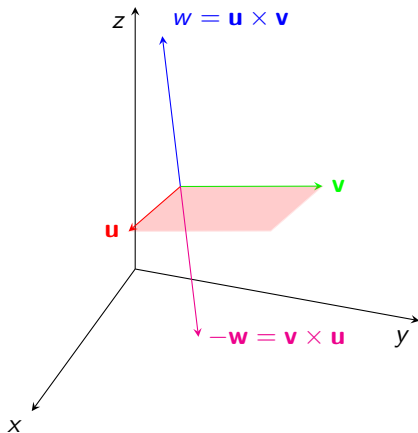
(iii) $(\mathbf{u}, \mathbf{v}, \mathbf{w})$ pos.suun.

Ominaisuuksia

$$\mathbf{v} \times \mathbf{u} = -\mathbf{u} \times \mathbf{v}$$

$$\mathbf{u} \times (\mathbf{a} + \mathbf{b}) = \mathbf{u} \times \mathbf{a} + \mathbf{u} \times \mathbf{b}$$

$$t(\mathbf{u} \times \mathbf{v}) = (t\mathbf{u}) \times \mathbf{v} = \mathbf{u} \times (t\mathbf{v})$$



\mathbf{w} on se vektori, jolle

$$(i) \mathbf{u} \cdot \mathbf{w} = 0, \quad \mathbf{v} \cdot \mathbf{w} = 0$$

$$(ii) |\mathbf{w}| = |\mathbf{u}||\mathbf{v}| \sin \theta$$

(iii) $(\mathbf{u}, \mathbf{v}, \mathbf{w})$ pos.suun.

Ominaisuuksia

$$\mathbf{v} \times \mathbf{u} = -\mathbf{u} \times \mathbf{v}$$

$$\mathbf{u} \times (\mathbf{a} + \mathbf{b}) = \mathbf{u} \times \mathbf{a} + \mathbf{u} \times \mathbf{b}$$

$$t(\mathbf{u} \times \mathbf{v}) = (t\mathbf{u}) \times \mathbf{v} = \mathbf{u} \times (t\mathbf{v})$$