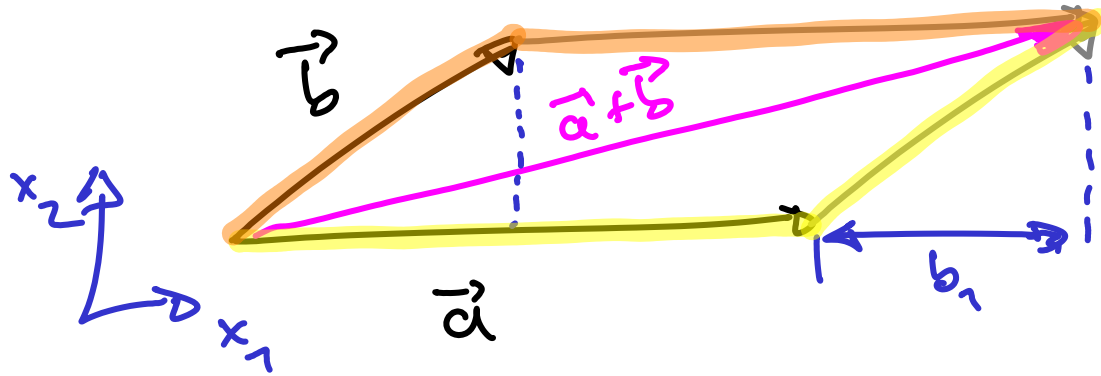


$$\vec{u} = \begin{pmatrix} u_1 \\ u_2 \end{pmatrix} = \begin{pmatrix} 4 \\ 2 \end{pmatrix}$$

$$|\vec{u}| = \sqrt{4^2 + 2^2} = \sqrt{20} = 2\sqrt{5}$$

Betrag des Vektors  
Länge des Pfeils



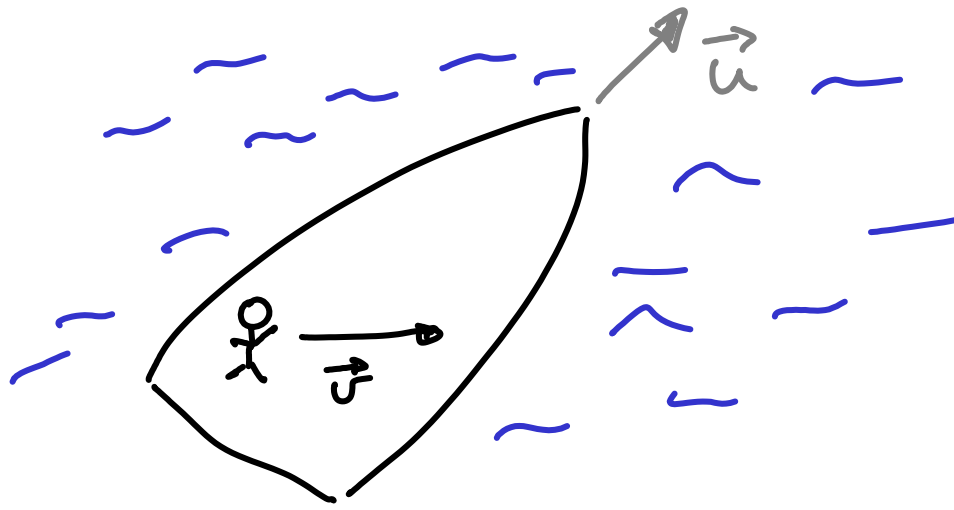
$$\vec{a} = \begin{pmatrix} a_1 \\ a_2 \end{pmatrix}$$

$$\vec{b} = \begin{pmatrix} b_1 \\ b_2 \end{pmatrix}$$

$$\vec{a} + \vec{b} = \vec{b} + \vec{a}$$

$$\vec{a} = \begin{pmatrix} 4 \\ 0 \end{pmatrix}, \quad \vec{b} = \begin{pmatrix} 2 \\ 2 \end{pmatrix}$$

$$\vec{a} + \vec{b} = \begin{pmatrix} 4+2 \\ 0+2 \end{pmatrix} = \begin{pmatrix} 6 \\ 2 \end{pmatrix}$$

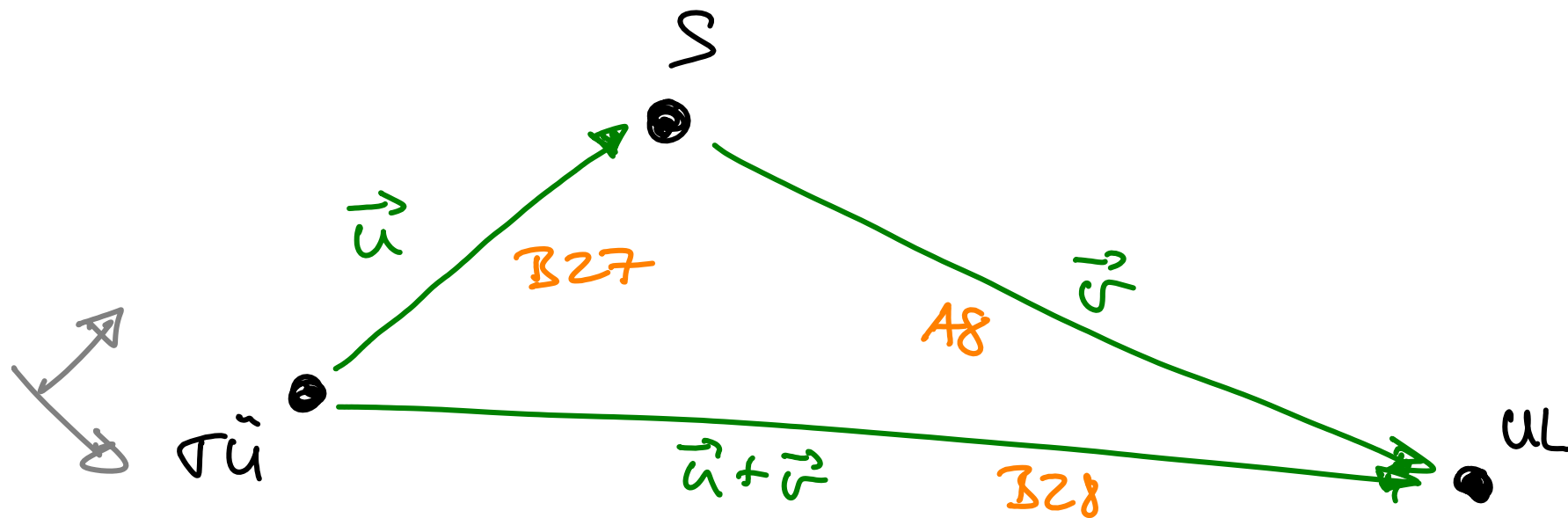
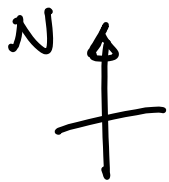


$\vec{v}$  : Geschw. der Person  
auf der Schiff

$\vec{u}$  : Geschw. des Schiffs  
bzgl. Wasser

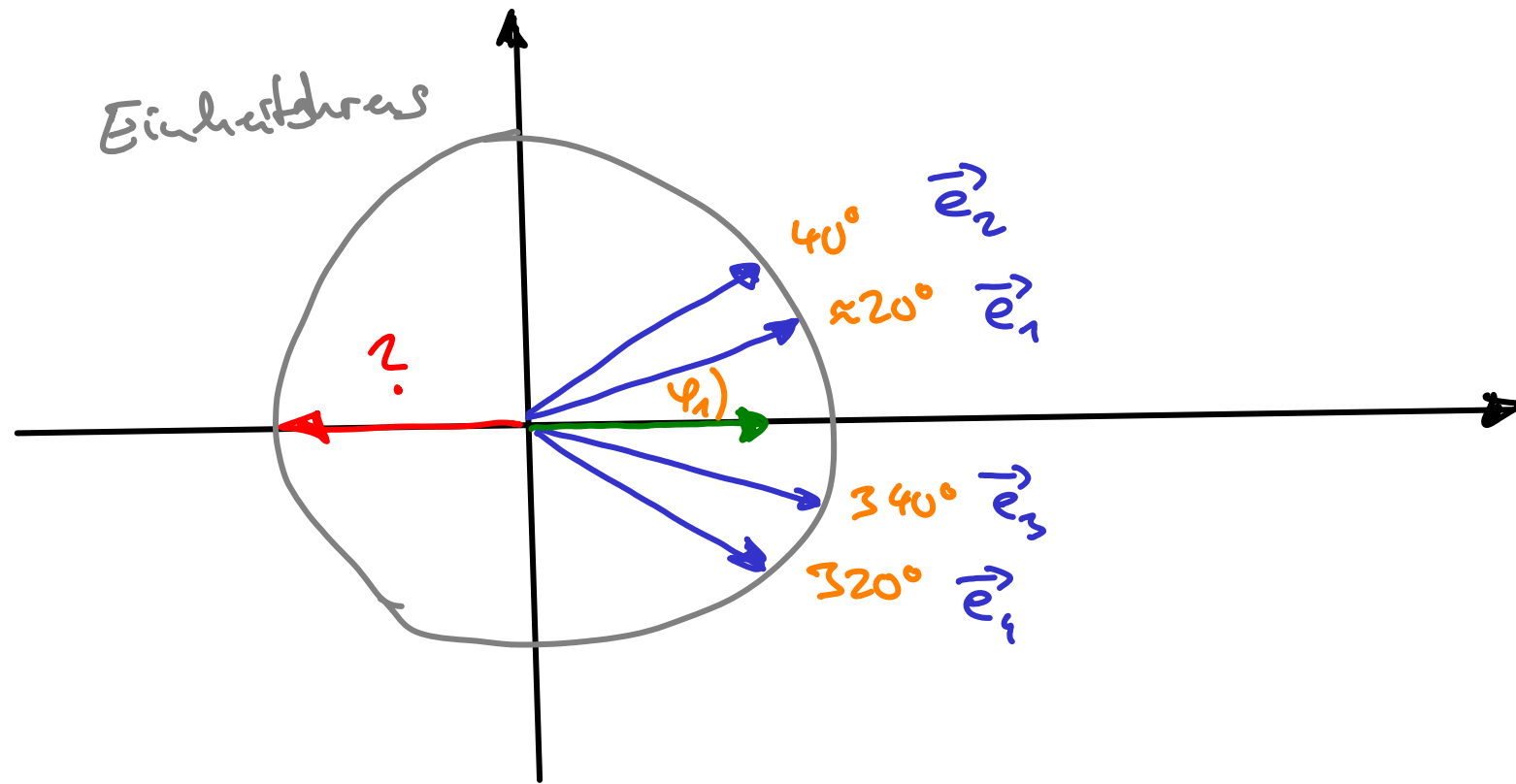
 : Geschw. Person gegenüber Wasser

The diagram shows a vector addition. A black arrow points upwards and to the right. A pink arrow points upwards and to the right, starting from the same origin as the black arrow. A longer pink arrow, representing the sum of the two, points upwards and to the right, starting from the same origin as the black arrow. The label  $\vec{u} + \vec{v}$  is written below the longer pink arrow.



$$\vec{u} = \begin{pmatrix} 0 \\ 50 \end{pmatrix} \text{ km}, \quad \vec{s} = \begin{pmatrix} 100 \text{ km} \\ 0 \end{pmatrix}$$

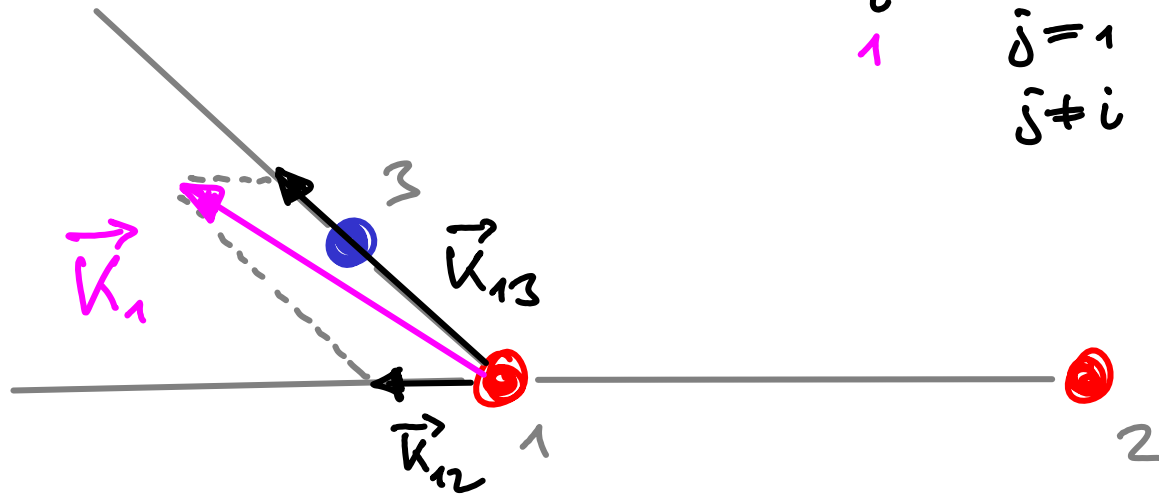
$$|\vec{u} + \vec{s}| = \left| \begin{pmatrix} 100 \\ 50 \end{pmatrix} \right| \text{ km} = \sqrt{10000 \text{ km}^2 + 2500 \text{ km}^2} \\ \approx 110 \text{ km}$$



$$\bar{\varphi} = \frac{\varphi_1 + \varphi_2 + \varphi_3 + \varphi_4}{4} = \underline{180^\circ}$$

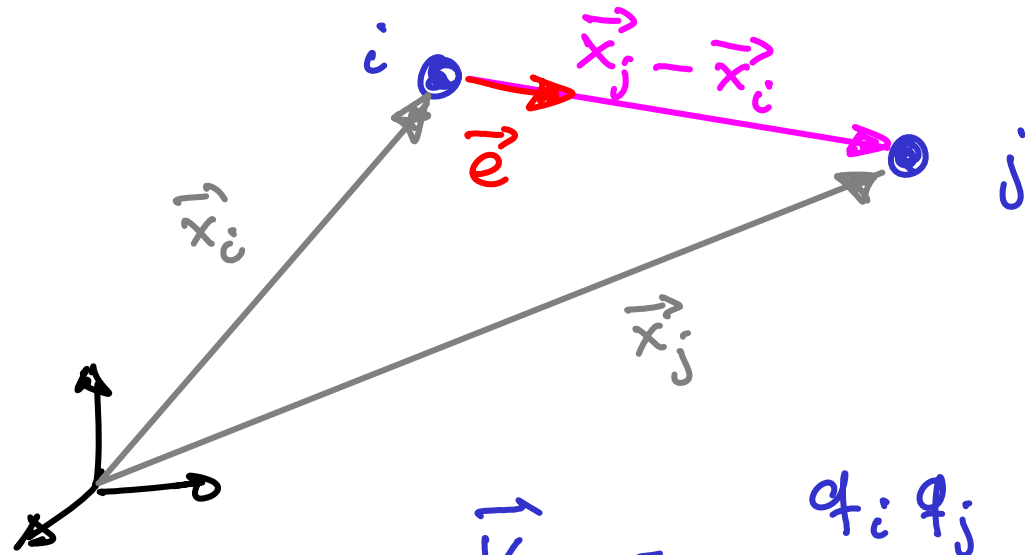
$$\underline{\bar{e}} = \frac{\vec{e}_1 + \vec{e}_2 + \vec{e}_3 + \vec{e}_4}{4} \quad \leftarrow \underline{\text{besser!}}$$

Pfeile addieren, geht ohne Koordinatensystem  
ohne Referenzrichtung



$$\vec{K}_1 = \sum_{\substack{j=1 \\ j \neq i}}^N \vec{K}_{ij} = \sum_{j=2}^N \vec{K}_{1j}$$

Gesamtkraft auf Testladung 1:  $i=1, N=3$



$$|\vec{e}| = 1$$

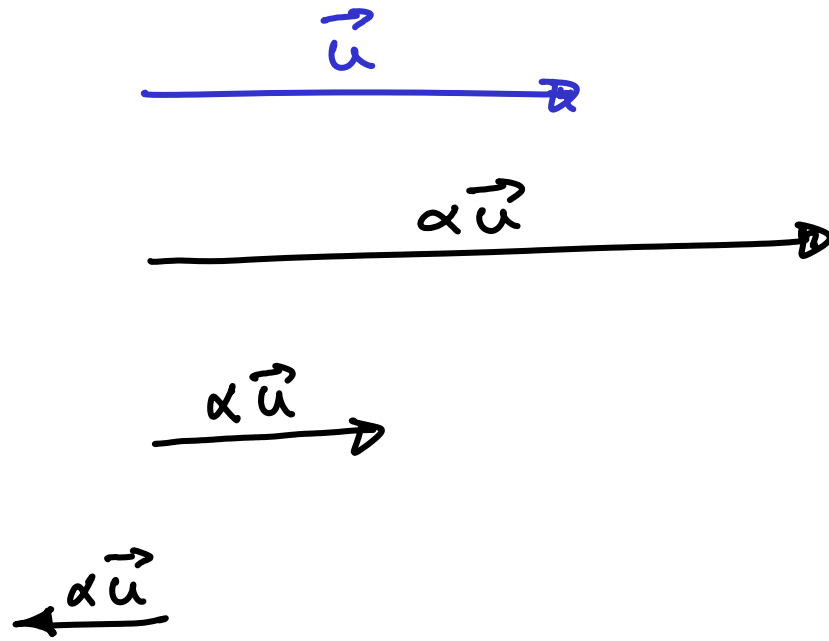
$$\vec{K}_{ij} = \frac{q_i q_j}{|\vec{x}_i - \vec{x}_j|^2} \vec{e}$$

$$\vec{e} = \frac{\vec{x}_j - \vec{x}_i}{|\vec{x}_j - \vec{x}_i|} \quad \text{damit} \quad \vec{K}_{ij} = q_i q_j \frac{\vec{x}_j - \vec{x}_i}{|\vec{x}_j - \vec{x}_i|^3}$$

$\alpha > 1$ :

$0 < \alpha < 1$ :

$-1 < \alpha < 0$ :

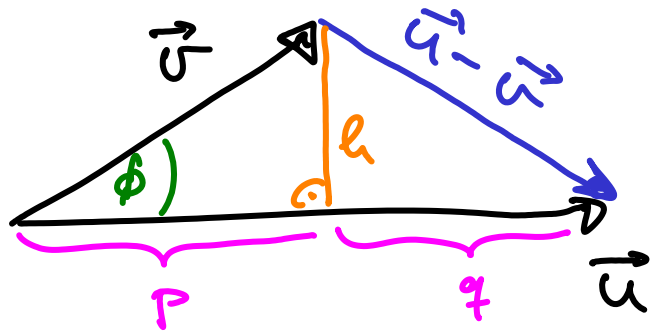


alle parallel  
(bzw. anti-  
parallel)



$$\vec{u} = \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}, \quad \vec{v} = \begin{pmatrix} 0 \\ 1 \\ -1 \end{pmatrix}$$

$$\vec{u} \cdot \vec{v} = 1 \cdot 0 + 2 \cdot 1 + 3 \cdot (-1) = -1$$



$$\cos \phi = \frac{p}{|v|}$$

Pythagoras:  $p^2 + \underline{h^2} = |v|^2$  ,  $q^2 + \underline{h^2} = |u - v|^2$

$$\Rightarrow |v|^2 - p^2 = |u - v|^2 - q^2$$

$q = |u| - p$   
 $q^2 = |u|^2 + p^2 - 2|u|p$

$$\Leftrightarrow \underline{|v|^2 - p^2} = (u - v) \cdot (u - v) - |u|^2 - \underline{p^2} + 2|u|p$$

$$\Leftrightarrow \underline{|v|^2} = \underline{|u|^2} + \underline{|v|^2} - \underline{2u \cdot v} - \underline{|u|^2} + \underline{2|u|p}$$

$$\Leftrightarrow u \cdot v = |u| \cdot p = |u| |v| \cos \phi$$

$p = |v| \cos \phi$