

# task\_5.2.1\_with\_calc

## Student Group

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### Task 5.2.1 Multiple Forces on a Charge I (exam task, ca 8% of a 60-minute exam, WS2020)



Given is the arrangement of electric charges in the picture on the right.

The following force effects result:

$$F_{01} = -5 \text{ N}$$

$$F_{02} = -6 \text{ N}$$

$$F_{03} = +3 \text{ N}$$

Calculate the magnitude of the resulting force.

Tips for the Solution

- How have the forces be prepared, to add them correctly?

Solution

$$F_0 = |\vec{F}_0| \quad \text{with } \vec{F}_0 = \left( \begin{matrix} F_{x,0} \\ F_{y,0} \end{matrix} \right) = \left( \sum_{n=1}^N F_{x,0n} \quad \sum_{n=1}^N F_{y,0n} \right) \quad F_0 = \sqrt{\left( \sum_{n=1}^N F_{x,0n} \right)^2 + \left( \sum_{n=1}^N F_{y,0n} \right)^2}$$

The forces have to be resolved into coordinates. Here, it is recommended to use an orthogonal coordinate system ( $x$  and  $y$ ).

The coordinate system shall be in such a way, that the origin lies in  $Q_0$ , the  $x$ -axis is directed towards  $Q_3$  and the  $y$ -axis is orthogonal to it.

For the resolution of the coordinates, it is necessary to get the angles  $\alpha_{0n}$  of the forces with respect to the x-axis.

In the chosen coordinate system this leads to:  $\alpha_{0n} = \arctan(\frac{\Delta y}{\Delta x})$

$$\alpha_{01} = \arctan(\frac{3}{1}) = 1.249 = 71.6^\circ$$

$$\alpha_{02} = \arctan(\frac{4}{3}) = 0.927 = 53.1^\circ$$

$$\alpha_{03} = \arctan(\frac{0}{3}) = 0 = 0^\circ$$

Consequently, the resolved forces are:

$$\begin{aligned} F_{x,0} &= F_{x,01} + F_{x,02} + F_{x,03} \quad | \quad \text{with } F_{x,0n} \\ &= F_{0n} \cdot \cos(\alpha_{0n}) \quad | \quad F_{x,0} = (-5 \text{ N}) \cdot \cos(71.6^\circ) + (-6 \text{ N}) \\ &\cdot \cos(53.1^\circ) + (+3 \text{ N}) \cdot \cos(0^\circ) \quad | \quad F_{x,0} = -9.54 \text{ N} \\ F_{y,0} &= F_{y,01} + F_{y,02} + F_{y,03} \quad | \quad \text{with } F_{y,0n} = F_{0n} \cdot \sin(\alpha_{0n}) \\ F_{y,0} &= (-5 \text{ N}) \cdot \sin(71.6^\circ) + (-6 \text{ N}) \cdot \sin(53.1^\circ) \\ &+ (+3 \text{ N}) \cdot \sin(0^\circ) \quad | \quad F_{y,0} = -2.18 \text{ N} \end{aligned}$$

Result

$$F_0 = \sqrt{(-9.54 \text{ N})^2 + (-2.18 \text{ N})^2} = 9.79 \text{ N} \\ \rightarrow 9.8 \text{ N}$$

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