

# task\_elndbo3xwi2klxuu\_with\_calculation

## Student Group

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lorenz force, exam ee2 SS2021

**Exercise E1 Lorentz Force (hard!)  
(written test, approx. 10 % of a 120-minute written test, SS2021)**

A 300 picture below shows a straight high voltage direct current transmission line with a current of 2000 A. The resulting force is independent of the length of the conductor.

A homogeneous geomagnetic field is assumed. The magnetic field strength has a vertical component of  $B_{\text{v}} = 40 \mu\text{T}$  and a horizontal component of  $B_{\text{h}} = 20 \mu\text{T}$ .

The angle between the transmission line and the horizontal component of the field strength is  $\alpha = 20^\circ$ .

The picture on the right shows the line (black), the field strength components, and the angle in front and top view for illustration purposes.

Top View

**Path**

a) Calculate the force that results from the current flow on the entire conductor. First, calculate the vertical and horizontal components and combine them accordingly.

For the resulting current the direction of the path has to be considered with the right-hand rule:

$$I_{(1)} = +I_2 - I_1 - I_3 \quad \rightarrow \quad \theta_{(1)} = 2 \text{ A} - 5 \text{ A} - 1 \text{ A}$$

$$I_{(2)} = +I_3 + I_4 - I_1 \quad \rightarrow \quad \theta_{(2)} = 1 \text{ A} + 4 \text{ A} - 5 \text{ A}$$

The force on the transmission line can be calculated via the Lorentz force  $\vec{F} = I \cdot (\vec{l} \times \vec{B})$

$$\begin{aligned} \text{end{align}} &= +I_3 - I_4 - I_2 \quad \rightarrow \quad \theta_{(3)} = 1 \text{ A} - 4 \\ & \text{A} - 2 \text{ A} \end{aligned}$$

Here, we have two components for the current - and therefore for the force - to evaluate.

Considering the right-hand rule (and the cross product), the vertical field  $B_{\text{v}}$  generates a horizontal force  $F_{\text{h}}$  and vice versa.

The horizontal component is given by 
$$F_{\text{h}} = I \cdot (I \cdot B_{\text{v}})$$

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