

# task\_ludzwiuhjxitz85b\_with\_calculation

## Student Group

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induction, flux, induced voltage, exam ee2 SS2021

### Exercise E1 effect of induction (written test, approx. 5 % of a 120-minute written test, SS2021)

A single conductor loop is penetrated by a changing magnetic flux.

The following figure shows the variation of the flux  $\Phi(t)$  over time.

Calculate the variation of the induced voltage  $U_{\text{ind}}(t)$  over time and draw it in a separate diagram.

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Path

Based on Faraday's Law of Induction the induced voltage is given by: 
$$U_{\text{ind}} = - \frac{d}{dt} \Psi(t) = - \frac{d}{dt} \Phi(t)$$

For a linear function, the derivative can be substituted by Deltas ( $d \rightarrow \Delta$ ):

$$U_{\text{ind}} = - \frac{\Delta \Phi(t)}{\Delta t} = - \frac{\Phi(t_{n+1}) - \Phi(t_n)}{t_{n+1} - t_n}$$

For a piece-wise linear function, the induced voltage can be calculated for each interval.

Here, there are 5 different intervals - in the following called  $I$  to  $V$  from left to right:

\$\$\dots\$\$

- For the intervals  $I$ ,  $III$ , and  $V$ , the flux  $\Phi(t)$  is constant. Therefore,  $\Delta \Phi(t) = 0$  and  $U_{\text{ind}}(t) = 0$  for  $V$ .

\$\$\dots\$\$

- For the interval  $\Delta t$ :

- The change in the flux is:  $\Delta \Phi(t) = 1.5 \cdot 10^{-4} \text{ Vs} - 4.5 \cdot 10^{-4} \text{ Vs} = -3.0 \cdot 10^{-4} \text{ Vs}$
- The time span is:  $0.2 \text{ s}$
- Conclusively, the induced voltage is:  $U_{\text{ind}}(t) = + \frac{3.0 \cdot 10^{-4} \text{ Vs}}{0.2 \text{ s}} = 1.5 \text{ mV}$

- For the interval  $\text{IV}$ :
  - The change in the flux is:  $\Delta \Phi(t) = 0 \cdot 10^{-4} \text{ Vs} - 1.5 \cdot 10^{-4} \text{ Vs} = -1.5 \cdot 10^{-4} \text{ Vs}$
  - The time span is:  $0.2 \text{ s}$
  - Conclusively, the induced voltage is:  $U_{\text{ind}}(t) = + \frac{1.5 \cdot 10^{-4} \text{ Vs}}{0.2 \text{ s}} = 0.75 \text{ mV}$

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