

# task\_ludzwiuhjxitz85b\_with\_calculation

## Student Group

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induction, flux, induced voltage, exam ee2 SS2021

### Exercise E11 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.

\$\$u\_{\text{ind}}(t) = - \frac{d\Phi(t)}{dt}

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Path

Based on Faraday's Law of Induction the induced voltage is given by: 
$$u_{\text{ind}} = - \frac{d\Phi(t)}{dt} = - \frac{d}{dt} \left( \sum_{n=1}^N \Phi_n(t) \right)$$

For a linear function, the derivative can be substituted by  $\Delta$  ( $\frac{d}{dt} \rightarrow \frac{\Delta}{\Delta t}$ ):

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

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\text{in}\\$\dots

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

\$\$\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  $\Delta t$ :
  - 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:  $u_{\text{ind}}(t) = + \frac{1.5 \cdot 10^{-4} \text{ Vs}}{0.2 \text{ s}} = 0.75 \text{ mV}$

\$\$\dots\$

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