How to Generate Personalized Tasks and Sample Solutions for Anonymous Peer Review in Electrical Engineering using LaTeX, PGFPLOTS and CircuiTikZ

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Survey

What field are you from?

1. mathematics, computer science, technology
2. education and teaching
3. medicine and care
4. languages and media
5. banking and insurance
6. anything else

Organizational Matters

Slides:

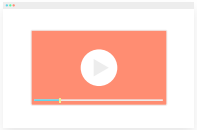
yes

Organizational Matters

Slides:

yes

Recording:



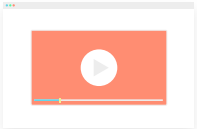
yes

Organizational Matters

Slides:

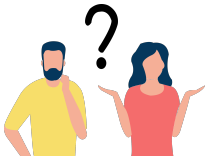
yes

Recording:



yes

Questions:



with pleasure

Overview

Why all this?

How are the tasks generated in LaTeX?
- Topic „Charge and Current“
- Topic „Nodal Analysis“

What has come out of it?

Why all this?

Traditional Performance Assessments

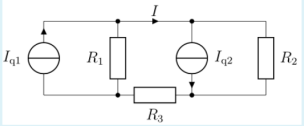
Source: https://pixabay.com/de/photos/taschenrechner-notizblock-1687962/

Demands in the Working World

Source: https://pixabay.com/de/arbeitsplatz-team-gesch%C3%A4ftstreffen-1245776/

Classical E-Learning Tasks

Mit Hilfe der Zweipoltheorie soll der Strom I berechnet werden.



Werte der Bauelemente:

- I_{q1} = 6 A
- I_{q2} = 2 A
- R_1 = 8 Ω
- R_2 = 5 Ω
- R_3 = 8 Ω

Geben Sie den Strom in der Form "Zahlenwert Einheit" an. Als (optionaler) Einheitenvorsatz ist m (milli) und k (kilo) erlaubt.

Antwort: 2,76 A ✔

Die richtige Antwort ist: 2,76 A

Free Handwritten Solution

Zeitraum $0_s \leq t \leq 1_s$:

Strom: $i(t) = -3\frac{A}{s} \cdot t$

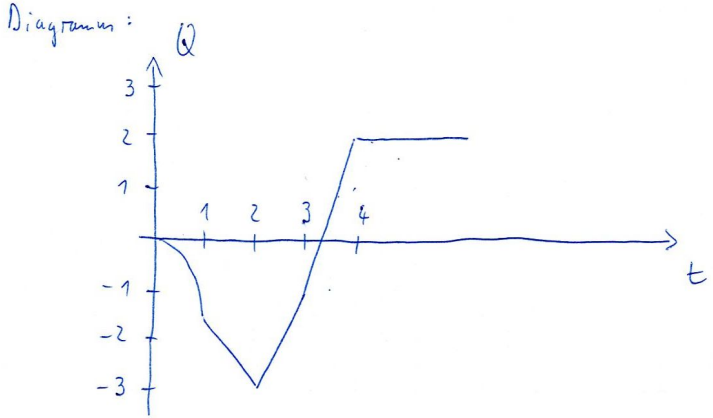
Ladung: $Q(t) = \int_0^t i(t)\,dt + Q(0)$

$= \int_0^t -3\frac{A}{s} \cdot t\,dt + 0$

$= \left[-3\frac{A}{s}\frac{t^2}{2}\right]_0^t = -\frac{3}{2}\frac{A}{s} \cdot t^2$

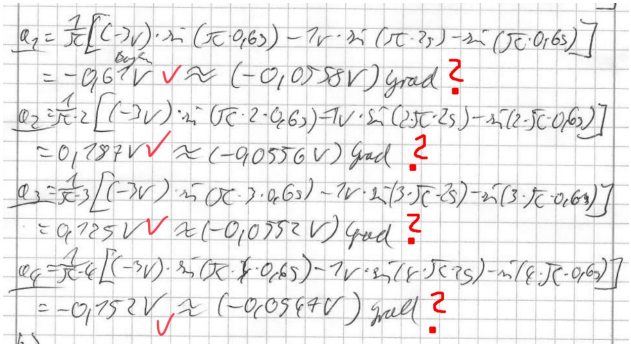
$Q(1s) = -1{,}5$

Free Handwritten Solution



Examples of Student Misconceptions

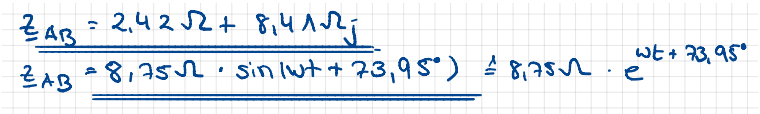
Specification of Fourier coefficients in V and V °:



also see: https://twitter.com/LehrstuhlEMV/status/1257605076308426753

Examples of Student Misconceptions

Complex impedance converted to time function:



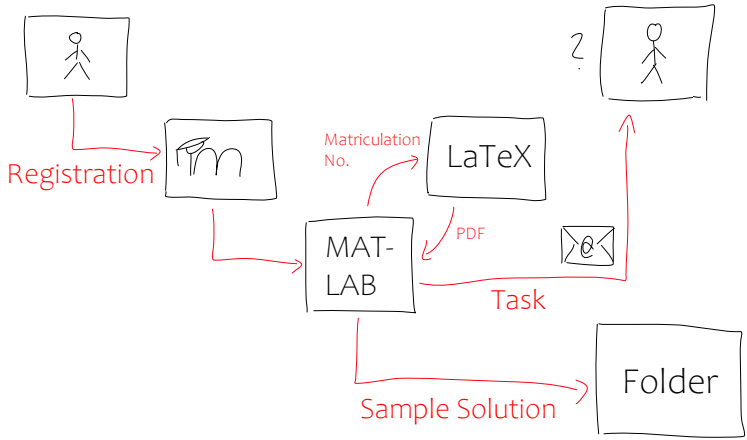
also see: https://twitter.com/LehrstuhlEMV/status/1264294433027174401

Idea

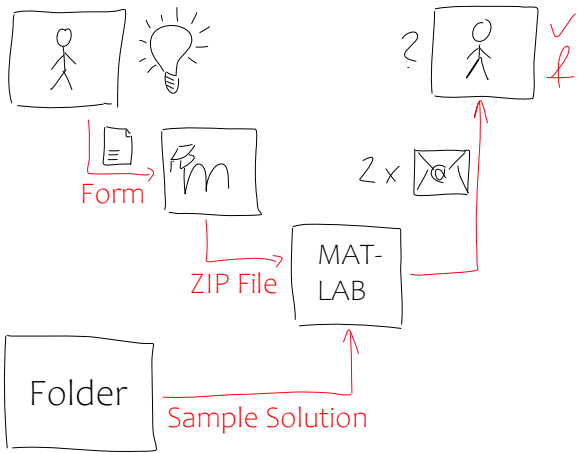
Personalizable tasks for handwritten solution:

- handwritten $\longrightarrow$ authentic, low-threshold for formulas, schematics, diagrams, misconceptions become visible
- personalized $\longrightarrow$ no plagiarism possible
- peer review $\longrightarrow$ no correction effort $\longrightarrow$ good ready-made personalized sample solution
- via Moodle and e-mail $\longrightarrow$ scalable, no „red tape“

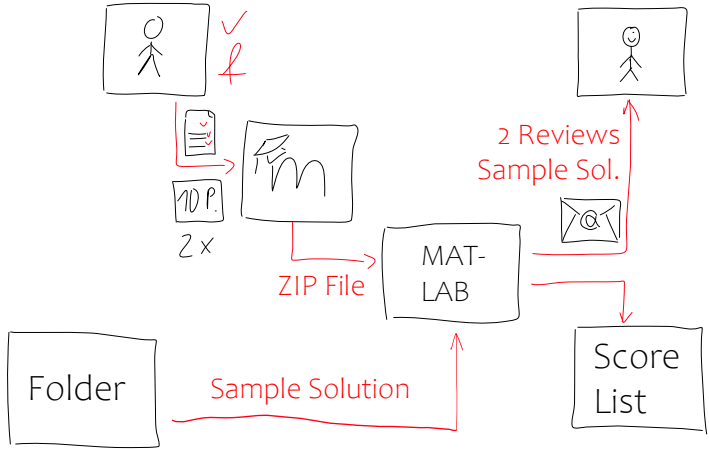
Creation and Sending of the Tasks



Submission and Distribution of the Solutions



Mutual Correction and Completion



How are the tasks generated in LaTeX?

1. Task (same for all)

The displayed time curve shows the current i as a function of time t. The charge $Q(t)$ is searched for the four sections

1. $0\,\mathrm{s} \leq t \leq 1\,\mathrm{s}$,
2. $1\,\mathrm{s} < t \leq 2\,\mathrm{s}$,
3. $2\,\mathrm{s} < t \leq 3\,\mathrm{s}$ and
4. $3\,\mathrm{s} < t \leq 4\,\mathrm{s}$.

The initial charge is $Q(t = 0) = 0$.

Calculate the charge $Q(t)$ for each section as a formula by integrating the current over time and draw the corresponding time curve.

Diagram (for Matriculation Number 123 456)

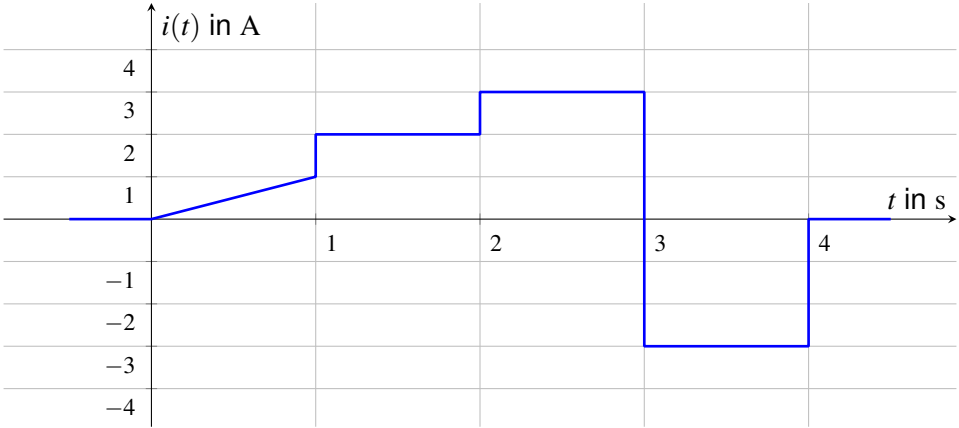


Diagram (for Matriculation Number 123 457)

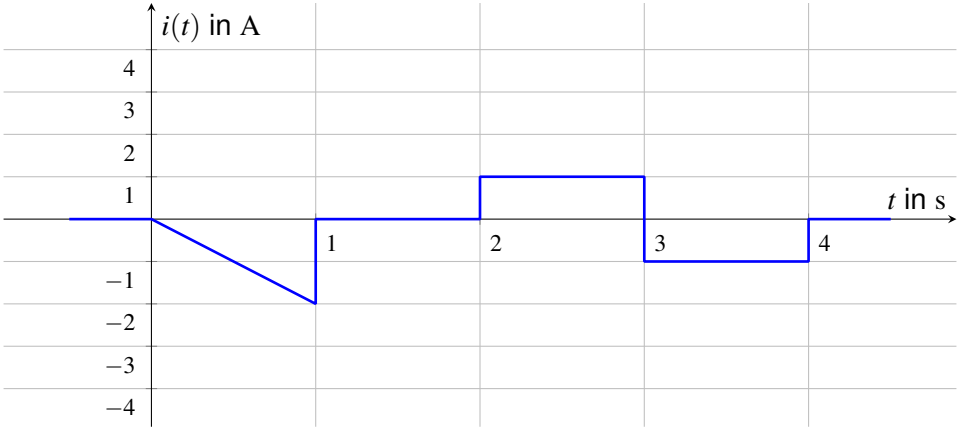


Diagram (for Matriculation Number 123 458)

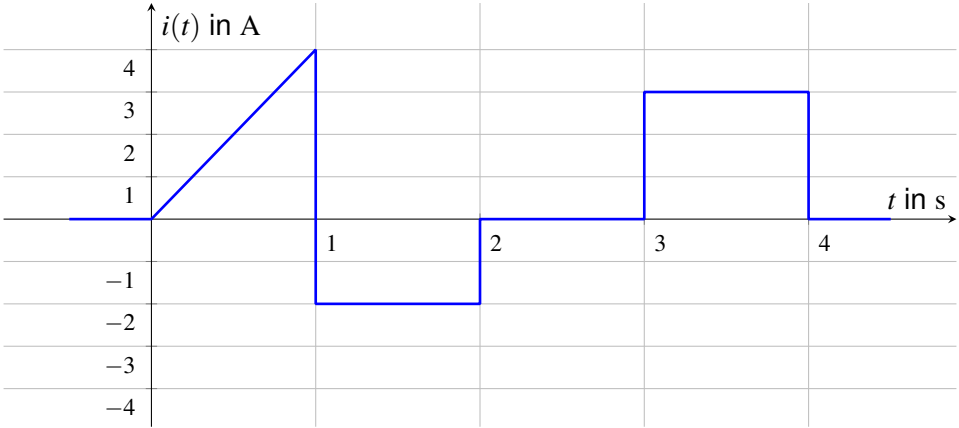
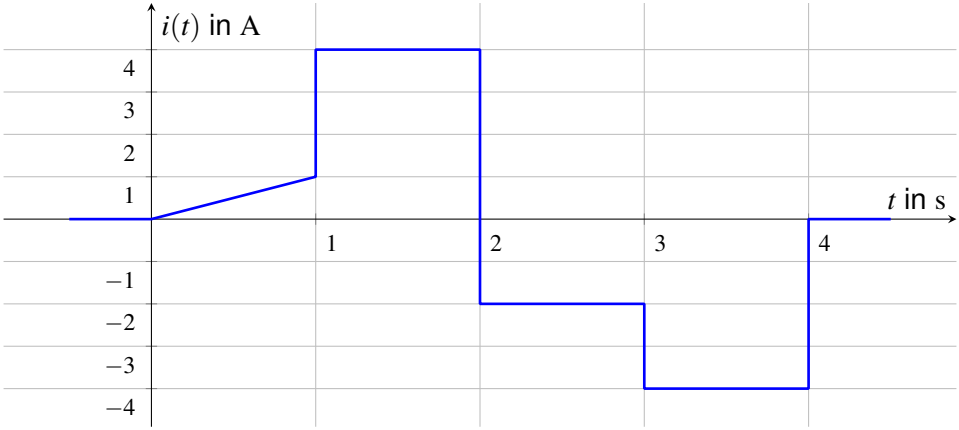


Diagram (for Matriculation Number 123 459)



Create Randomized PGFPLOTS Diagrams

```
\documentclass{standalone}
\usepackage{pgfplots,siunitx}
\begin{document}
% Set random number generator to matriculation number
\pgfmathsetseed{123456}
% Current at time 1 s (in A, can also still be zero, but should not be)
\pgfmathrandominteger{\stromeinsrandom}{-4}{4}
% if current is zero, set to 1 A
\pgfmathsetmacro{\stromeins}{ifthenelse(\stromeinsrandom==0,1,\stromeinsrandom)}
% Current in the period from 1 s to 2 s (in A, can also be zero)
\pgfmathrandominteger{\stromzwei}{-4}{4}
% Current in the period from 2 s to 3 s (in A, can also be zero)
\pgfmathrandominteger{\stromdreirandom}{-4}{4}
% if the current is equal to the value from the previous period, invert the sign
\pgfmathsetmacro{\stromdrei}{ifthenelse(\stromzwei==\stromdreirandom,-\stromdreirandom,\stromdreirandom)}
% if both currents are zero, set new current to 1 A
\pgfmathsetmacro{\stromdrei}{ifthenelse(abs(\stromzwei)+abs(\stromdrei)==0,1,\stromdrei)}
% Current in the period from 3 s to 4 s (in A, can also be zero)
\pgfmathrandominteger{\stromvierrandom}{-4}{4}
% if both currents are zero, set new current to 1 A
\pgfmathsetmacro{\stromvier}{ifthenelse(abs(\stromzwei)+abs(\stromvierrandom)==0,1,\stromvierrandom)}
% if both currents are zero, set new current to 1 A
\pgfmathsetmacro{\stromvier}{ifthenelse(abs(\stromdrei)+abs(\stromvier)==0,1,\stromvier)}
% if the current is equal to the value from the previous period, invert the sign
\pgfmathsetmacro{\stromvier}{ifthenelse(\stromdrei==\stromvier,-\stromvier,\stromvier)}
```

Create Randomized PGFPLOTS Diagrams

```
\begin{tikzpicture}
        \begin{axis}[
                xlabel={$t$ in \si{\second}},
                ylabel={$i(t)$ in \si{\ampere}},
                xmin=-0.9,xmax=4.9,ymin=-4.9,ymax=4.9,
                xtick={1,2,3,4},ytick={-4,-3,-2,-1,1,2,3,4},
                xticklabel style={below right},
                yticklabel style={below left},
                axis x line=middle,axis y line=center,
                xmajorgrids,ymajorgrids,]
                \addplot+[mark=none,line width=1pt] coordinates {
                        (-0.5,0)
                        (0,0)
                        (1,\stromeins)
                        (1,\stromzwei)
                        (2,\stromzwei)
                        (2,\stromdrei)
                        (3,\stromdrei)
                        (3,\stromvier)
                        (4,\stromvier)
                        (4,0)
                        (4.5,0)};
        \end{axis}
\end{tikzpicture}
\end{document}
```

1. Sample Solution (for Matriculation Number 123 456)

Sectionwise calculation:

$0 \leq t \leq 1\,\mathrm{s}$: Current in the 1. section (1 point):

$$i(t) = 1\,\frac{\mathrm{A}}{\mathrm{s}} \cdot t$$

Charge in the 1. section (1 point):

$$Q(t) = \int_0^t 1\,\frac{\mathrm{A}}{\mathrm{s}} t'\,\mathrm{d}t' + 0 = 1\,\frac{\mathrm{A}}{\mathrm{s}} \cdot \left[\frac{t'^2}{2}\right]_0^t = 0.5\,\frac{\mathrm{A}}{\mathrm{s}} t^2$$

Charge at the end of the 1. section (1 point):

$$Q(1\,\mathrm{s}) = 0.5\,\mathrm{A\,s}$$

1. Sample Solution (for Matriculation Number 123 457)

Sectionwise calculation:

$0 \leq t \leq 1\,\mathrm{s}$: Current in the 1. section (1 point):

$$i(t) = -2\,\frac{\mathrm{A}}{\mathrm{s}} \cdot t$$

Charge in the 1. section (1 point):

$$Q(t) = \int_0^t -2\,\frac{\mathrm{A}}{\mathrm{s}} t'\,\mathrm{d}t' + 0 = -2\,\frac{\mathrm{A}}{\mathrm{s}} \cdot \left[\frac{t'^2}{2}\right]_0^t = -1\,\frac{\mathrm{A}}{\mathrm{s}} t^2$$

Charge at the end of the 1. section (1 point):

$$Q(1\,\mathrm{s}) = -1\,\mathrm{A\,s}$$

1. Sample Solution (for Matriculation Number 123 458)

Sectionwise calculation:

$0 \leq t \leq 1\,\mathrm{s}$: Current in the 1. section (1 point):

$$i(t) = 4\,\frac{\mathrm{A}}{\mathrm{s}} \cdot t$$

Charge in the 1. section (1 point):

$$Q(t) = \int_0^t 4\,\frac{\mathrm{A}}{\mathrm{s}} t'\,\mathrm{d}t' + 0 = 4\,\frac{\mathrm{A}}{\mathrm{s}} \cdot \left[\frac{t'^2}{2}\right]_0^t = 2\,\frac{\mathrm{A}}{\mathrm{s}} t^2$$

Charge at the end of the 1. section (1 point):

$$Q(1\,\mathrm{s}) = 2\,\mathrm{A\,s}$$

1. Sample Solution (for Matriculation Number 123 459)

Sectionwise calculation:

$0 \leq t \leq 1\,\mathrm{s}$: Current in the 1. section (1 point):

$$i(t) = 1\,\frac{\mathrm{A}}{\mathrm{s}} \cdot t$$

Charge in the 1. section (1 point):

$$Q(t) = \int_0^t 1\,\frac{\mathrm{A}}{\mathrm{s}} t'\,\mathrm{d}t' + 0 = 1\,\frac{\mathrm{A}}{\mathrm{s}} \cdot \left[\frac{t'^2}{2}\right]_0^t = 0.5\,\frac{\mathrm{A}}{\mathrm{s}} t^2$$

Charge at the end of the 1. section (1 point):

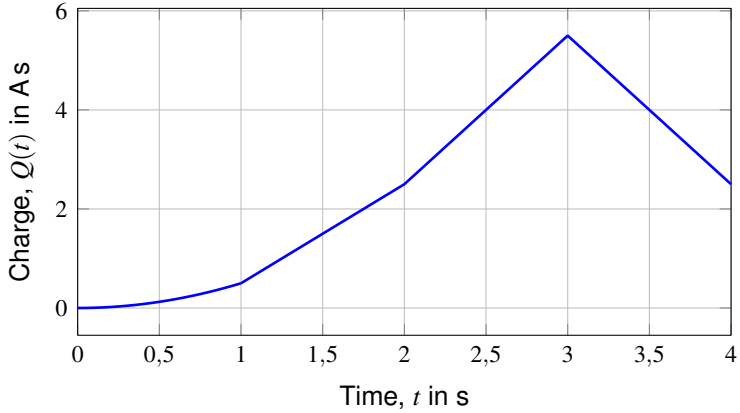
$$Q(1\,\mathrm{s}) = 0.5\,\mathrm{A\,s}$$

Algorithmic Generation of the Sample Solutions

```
% Truncate decimal places for an integer number
\pgfmathdeclarefunction{trimzero}{1}{\pgfmathparse{ifthenelse(#1==round(#1),int(#1),#1)}}
% Convert current (in A) to integers
\pgfmathsetmacro{\stromeins}{int(\stromeins)}
% Charge at the end of the 1st section (in As)
\pgfmathsetmacro{\ladungeins}{trimzero(\stromeins/2)}
% Differential operator (small upright d)
\newcommand*{\diff}{\mathop{}\!\mathrm{d}}

Current in the 1. section (1 point):
\begin{equation}
        i(t) = \SI{\stromeins}{\ampere\per\second} \cdot t
\end{equation}

Charge in the 1. section (1 point):
\begin{subequations}\begin{align}
        Q(t) &= \int \limits_0^t \SI{\stromeins}{\ampere\per\second} t' \diff t' + 0 \\
        &= \SI{\stromeins}{\ampere\per\second} \cdot \left[ \frac{t'^2}{2} \right]_0^t \\
        &= \SI{\ladungeins}{\ampere\per\second} t^2
\end{align}\end{subequations}

Charge at the end of the 1. section (1 point):
\begin{equation}
        Q(\SI{1}{\second}) = \SI{\ladungeins}{\ampere\second}
\end{equation}
```

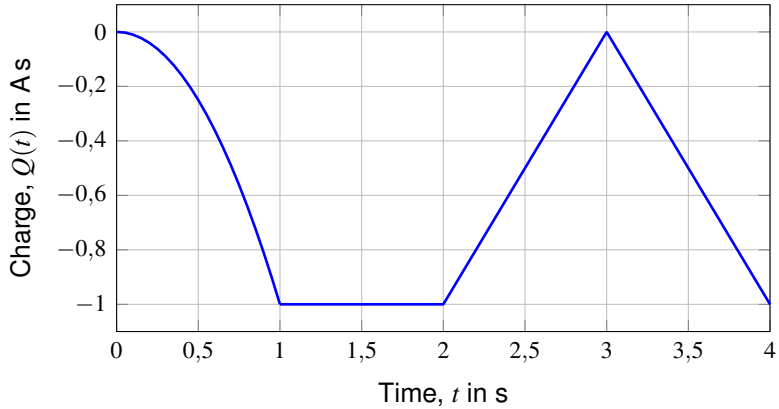
1. Sample Solution (for Matriculation Number 123 456)

Graphical representation:



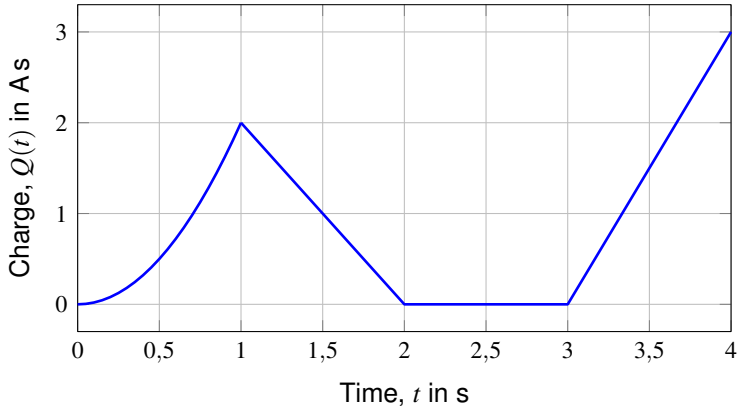
1. Sample Solution (for Matriculation Number 123 457)

Graphical representation:



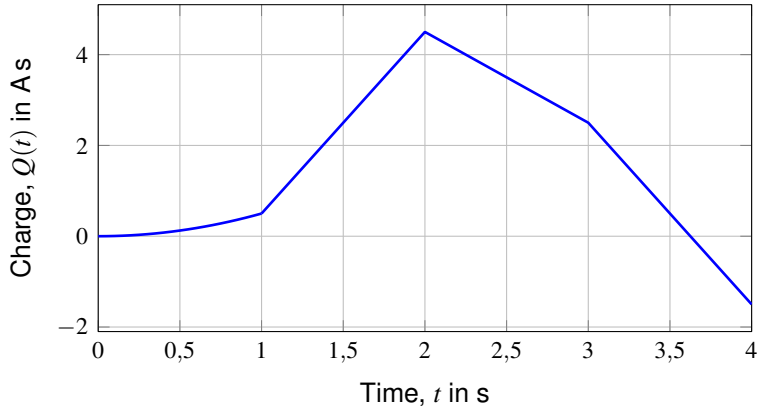
1. Sample Solution (for Matriculation Number 123 458)

Graphical representation:



1. Sample Solution (for Matriculation Number 123 459)

Graphical representation:



Survey

If you are also teaching, can you think of personalised/randomize tasks that can also be used for your subject?

1. yes, immediately, many
2. yes, some
3. yes, but only after some thought
4. no, not likely
5. nohow, no way

2. Task (same for all)

Nodal analysis shall be used to calculate the three nodal voltages U_{Kn1}, U_{Kn2} and U_{Kn3} between the respective node and the reference node.

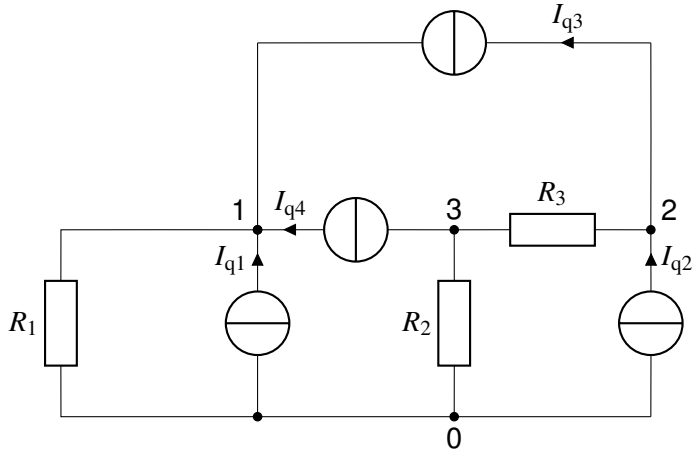
a) Draw the three nodal voltages U_{Kn1}, U_{Kn2} and U_{Kn3} in the circuit diagram (3 points).

b) Set up the system of equations to calculate the nodal voltages using nodal analysis in matrix form (9 points).

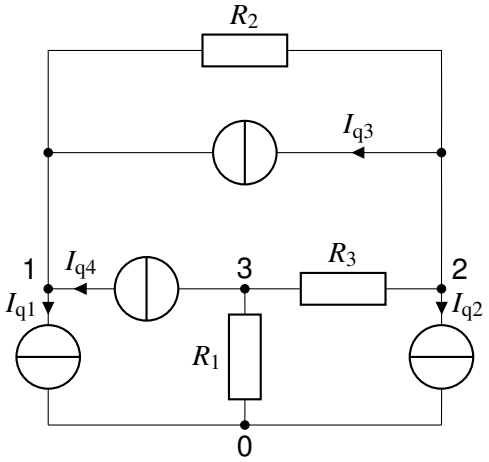
c) Insert the values of the components into the system of equations (1 point).

d) Solve the system of equations and thus calculate the three nodal voltages U_{Kn1}, U_{Kn2} and U_{Kn3} (3 points).

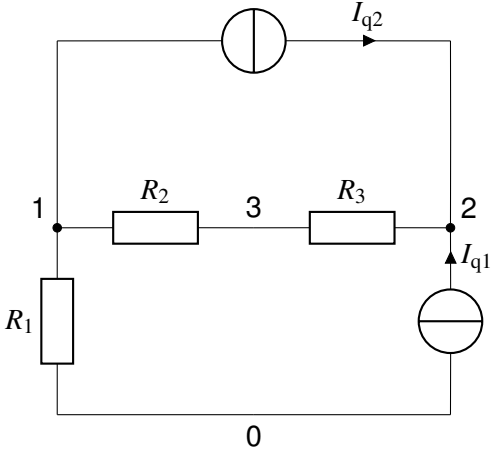
Circuit Diagram (for Matriculation Number 123 460)



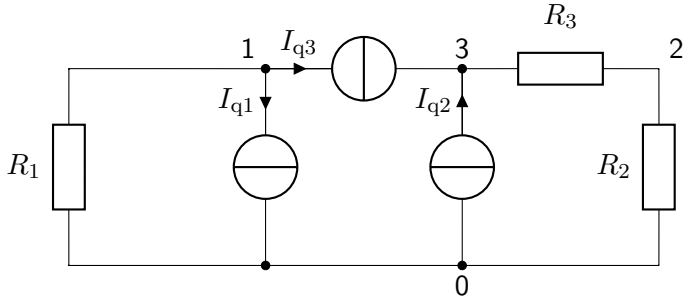
Circuit Diagram (for Matriculation Number 123 461)



Circuit Diagram (for Matriculation Number 123 462)



Circuit Diagram (for Matriculation Number 123 463)



Create Randomized CircuiTi*k*Z Circuits

```
\documentclass{standalone}
\usepackage{amsmath}
\newcommand{\ind}[1]{\mathrm{#1}}
\usepackage[european]{circuitikz}
\begin{document}
\begin{tikzpicture}[scale=1.3]
\draw (2,0) to[short] (0,0);
\draw (0,0) to[I, i^>=$I_{\ind{q}1}$] (0,2);
\draw (0,0) to[short, *-] (-2,0) to[R, l=$R_{1}$] (-2,2) to[short, -*] (0,2);
\draw (2,0) to[short] (4,0);
\draw (4,0) to[I, i_>=$I_{\ind{q}2}$] (4,2);
\draw (2,0) to[R, l^=$R_{2}$] (2,2);
\draw (0,2) to[short] (0,4);
\draw (0,4) to[I, i^<=$I_{\ind{q}3}$] (4,4);
\draw (4,4) to[short] (4,2);
\draw (0,2) to[I, i<^=$I_{\ind{q}4}$] (2,2);
\draw (4,2) to[R, l_=$R_{3}$] (2,2);
\node[circ] at (2,0) {};\node[below] at (2,0) {0};
\node[circ] at (0,2) {};\node[above left] at (0,2) {1};
\node[circ] at (4,2) {};\node[above right] at (4,2) {2};
\node[circ] at (2,2) {};\node[above] at (2,2) {3};
\end{tikzpicture}
\end{document}
```

2. Sample Solution (for Matriculation Number 123 460)

Set up the system of equations to calculate the network:

$$\begin{bmatrix} G_1 & 0 & 0 \\ 0 & G_3 & -G_3 \\ 0 & -G_3 & G_2 + G_3 \end{bmatrix} \cdot \begin{bmatrix} U_{\mathrm{Kn1}} \\ U_{\mathrm{Kn2}} \\ U_{\mathrm{Kn3}} \end{bmatrix} = \begin{bmatrix} I_{\mathrm{q1}} + I_{\mathrm{q3}} + I_{\mathrm{q4}} \\ I_{\mathrm{q2}} - I_{\mathrm{q3}} \\ -I_{\mathrm{q4}} \end{bmatrix}$$

Insert the values of the components into the system of equations:

$$\begin{bmatrix} 9\,\mathrm{S} & 0 & 0 \\ 0 & 7\,\mathrm{S} & -7\,\mathrm{S} \\ 0 & -7\,\mathrm{S} & 13\,\mathrm{S} \end{bmatrix} \cdot \begin{bmatrix} U_{\mathrm{Kn1}} \\ U_{\mathrm{Kn2}} \\ U_{\mathrm{Kn3}} \end{bmatrix} = \begin{bmatrix} 11\,\mathrm{A} \\ -3\,\mathrm{A} \\ -5\,\mathrm{A} \end{bmatrix}$$

2. Sample Solution (for Matriculation Number 123 461)

Set up the system of equations to calculate the network:

$$\begin{bmatrix} G_2 & -G_2 & 0 \\ -G_2 & G_2+G_3 & -G_3 \\ 0 & -G_3 & G_1+G_3 \end{bmatrix} \cdot \begin{bmatrix} U_{\mathrm{Kn1}} \\ U_{\mathrm{Kn2}} \\ U_{\mathrm{Kn3}} \end{bmatrix} = \begin{bmatrix} -I_{\mathrm{q1}}+I_{\mathrm{q3}}+I_{\mathrm{q4}} \\ -I_{\mathrm{q2}}-I_{\mathrm{q3}} \\ -I_{\mathrm{q4}} \end{bmatrix}$$

Insert the values of the components into the system of equations:

$$\begin{bmatrix} 8\,\mathrm{S} & -8\,\mathrm{S} & 0 \\ -8\,\mathrm{S} & 16\,\mathrm{S} & -8\,\mathrm{S} \\ 0 & -8\,\mathrm{S} & 14\,\mathrm{S} \end{bmatrix} \cdot \begin{bmatrix} U_{\mathrm{Kn1}} \\ U_{\mathrm{Kn2}} \\ U_{\mathrm{Kn3}} \end{bmatrix} = \begin{bmatrix} 4\,\mathrm{A} \\ -15\,\mathrm{A} \\ -8\,\mathrm{A} \end{bmatrix}$$

2. Sample Solution (for Matriculation Number 123 462)

Set up the system of equations to calculate the network:

$$\begin{bmatrix} G_1 + G_2 & 0 & -G_2 \\ 0 & G_3 & -G_3 \\ -G_2 & -G_3 & G_2 + G_3 \end{bmatrix} \cdot \begin{bmatrix} U_{\mathrm{Kn1}} \\ U_{\mathrm{Kn2}} \\ U_{\mathrm{Kn3}} \end{bmatrix} = \begin{bmatrix} -I_{\mathrm{q2}} \\ I_{\mathrm{q1}} + I_{\mathrm{q2}} \\ 0 \end{bmatrix}$$

Insert the values of the components into the system of equations:

$$\begin{bmatrix} 7\,\mathrm{S} & 0 & -4\,\mathrm{S} \\ 0 & 1\,\mathrm{S} & -1\,\mathrm{S} \\ -4\,\mathrm{S} & -1\,\mathrm{S} & 5\,\mathrm{S} \end{bmatrix} \cdot \begin{bmatrix} U_{\mathrm{Kn1}} \\ U_{\mathrm{Kn2}} \\ U_{\mathrm{Kn3}} \end{bmatrix} = \begin{bmatrix} -1\,\mathrm{A} \\ 2\,\mathrm{A} \\ 0 \end{bmatrix}$$

2. Sample Solution (for Matriculation Number 123 463)

Set up the system of equations to calculate the network:

$$\begin{bmatrix} G_1 & 0 & 0 \\ 0 & G_2 + G_3 & -G_3 \\ 0 & -G_3 & G_3 \end{bmatrix} \cdot \begin{bmatrix} U_{\mathrm{Kn1}} \\ U_{\mathrm{Kn2}} \\ U_{\mathrm{Kn3}} \end{bmatrix} = \begin{bmatrix} -I_{\mathrm{q1}} - I_{\mathrm{q3}} \\ 0 \\ I_{\mathrm{q2}} + I_{\mathrm{q3}} \end{bmatrix}$$

Insert the values of the components into the system of equations:

$$\begin{bmatrix} 7\,\mathrm{S} & 0 & 0 \\ 0 & 6\,\mathrm{S} & -3\,\mathrm{S} \\ 0 & -3\,\mathrm{S} & 3\,\mathrm{S} \end{bmatrix} \cdot \begin{bmatrix} U_{\mathrm{Kn1}} \\ U_{\mathrm{Kn2}} \\ U_{\mathrm{Kn3}} \end{bmatrix} = \begin{bmatrix} -6\,\mathrm{A} \\ 0 \\ 10\,\mathrm{A} \end{bmatrix}$$

Create Randomized Systems of Equations

```
\begin{equation*}
\begin{bmatrix}
G_{1} & 0 & 0 \\
0 & G_{3} & -G_{3} \\
0 & -G_{3} & G_{2} + G_{3}
\end{bmatrix} \cdot \begin{bmatrix}
U_{\ind{Kn}1} \\
U_{\ind{Kn}2} \\
U_{\ind{Kn}3}
\end{bmatrix} = \begin{bmatrix}
I_{\ind{q}1} + I_{\ind{q}3} + I_{\ind{q}4} \\
I_{\ind{q}2} - I_{\ind{q}3} \\
 - I_{\ind{q}4}
\end{bmatrix}
\end{equation*}
```

What has come out of it?

Evaluation of a Typical Cycle

Bare numbers:

- Tasks sent to about 200 students
- Solutions submitted by about 150 students
- Review carried out by about 140 students

Evaluation of a Typical Cycle

Bare numbers:

- Tasks sent to about 200 students
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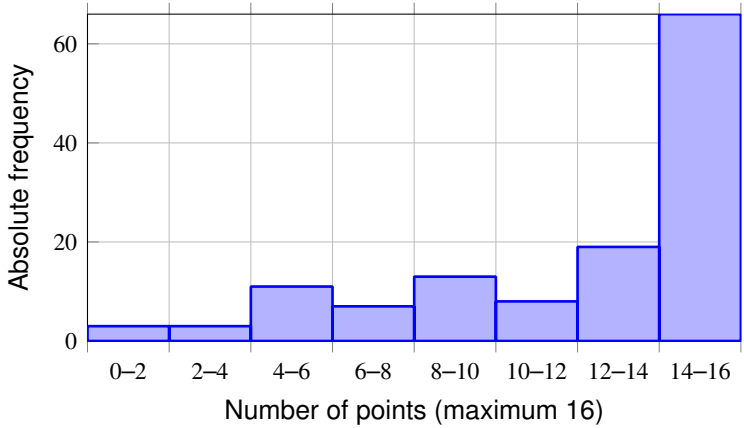
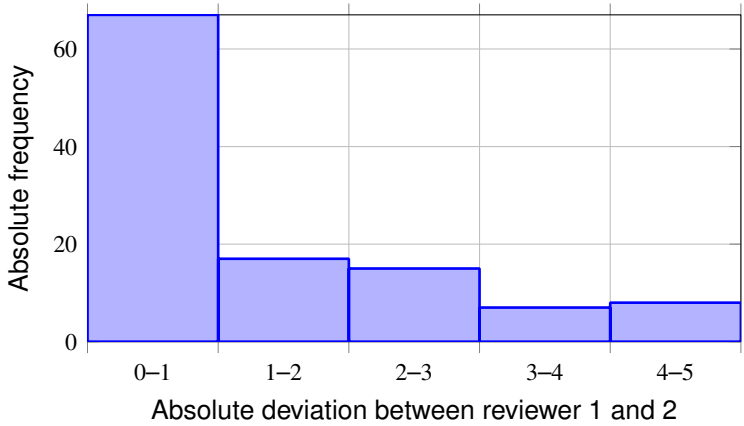
Advantage:

- excellent activation
- good exam preparation without „teaching to the test“

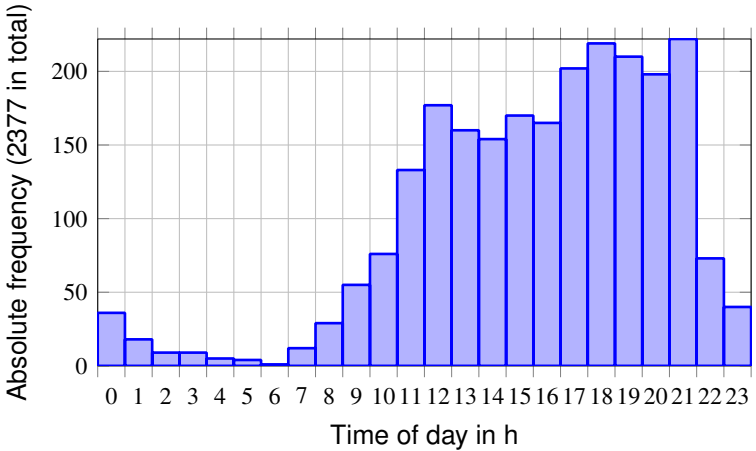
Typical Distribution of the Points



Typical Distribution of the Point Deviation



When Do Students Submit?



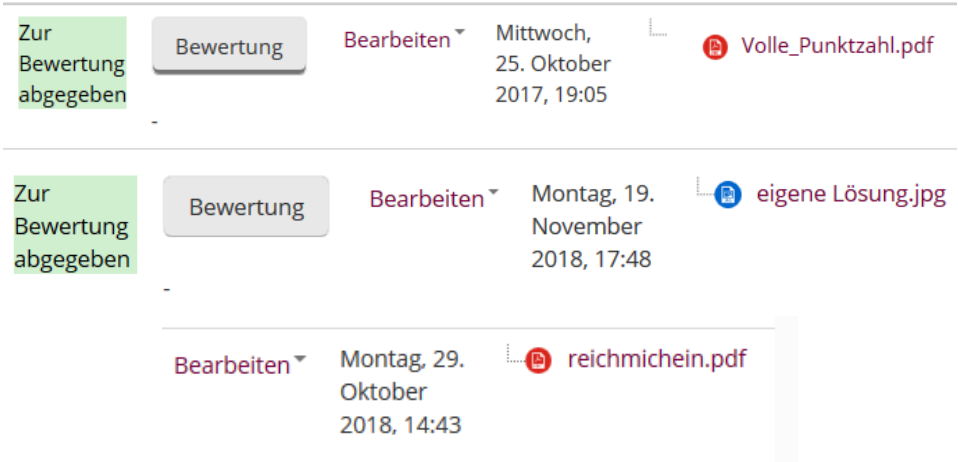
Fun Facts


Zur Bewertung abgegeben
Bewertung
Bearbeiten
Mittwoch, 25. Oktober 2017, 19:05
Volle_Punktzahl.pdf

Fun Facts


Zur Bewertung abgegeben
Bewertung
Bearbeiten
Mittwoch, 25. Oktober 2017, 19:05
Volle_Punktzahl.pdf
Zur Bewertung abgegeben
Bewertung
Bearbeiten
Montag, 19. November 2018, 17:48
eigene Lösung.jpg

Fun Facts


Zur Bewertung abgegeben
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Mittwoch, 25. Oktober 2017, 19:05
Volle_Punktzahl.pdf
Zur Bewertung abgegeben
Bewertung
Bearbeiten
Montag, 19. November 2018, 17:48
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Bearbeiten
Montag, 29. Oktober 2018, 14:43
reichmichein.pdf

Further Information

Achievements to date:

- 13 different task types developed so far
- 36 runs in 8 semesters so far
  - 6400 personalized tasks sent out
  - 3000 student solutions submitted
  - 5720 student peer reviews accomplished

Links (in German):

Lightning Talk:	`https://youtu.be/LDw_Ifmg2WM`
Twitter:	`#PersonalisierteAufgaben`
Article:	Die TEXnische Komödie 4/2019
FAQ:	SlideShare

Thank you very much for your attention!

Are there any questions?