Generation of Personalized Tasks and Corresponding Sample Solutions in MATLAB for Anonymous Peer Feedback in the Fundamentals of Electrical Engineering

MATLAB EXPO 2024

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Overview

Why all this?

How does it work?

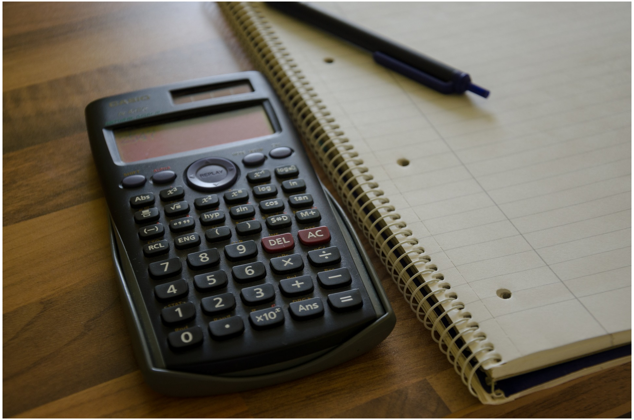
What does a typical task look like?
  Topic „Nodal Analysis“

Implementation in MATLAB

What came out of it?

Why all this?

Traditional Performance Assessments

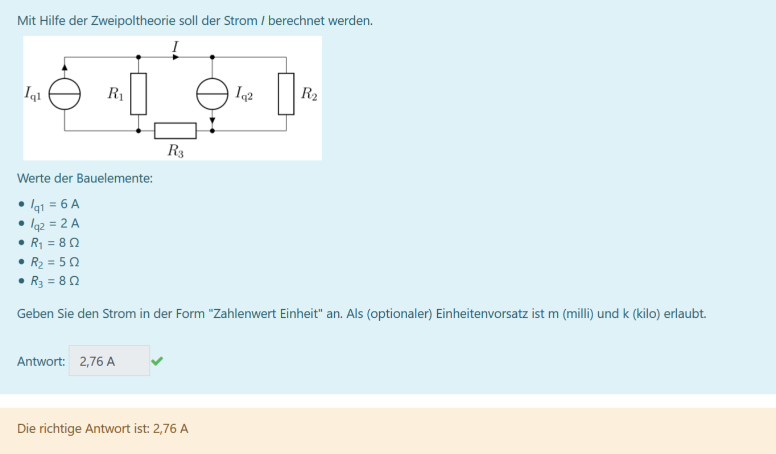


Source: `https://pixabay.com/de/photos/taschenrechner-notizblock-1687962/`

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:

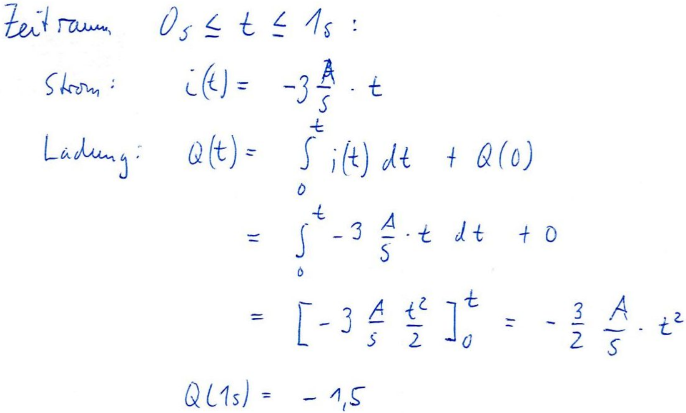
- I_{q1} = 6 A
- I_{q2} = 2 A
- R_1 = 8 Ω
- R_2 = 5 Ω
- R_3 = 8 Ω

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 $0_s \le t \le 1_s$:

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

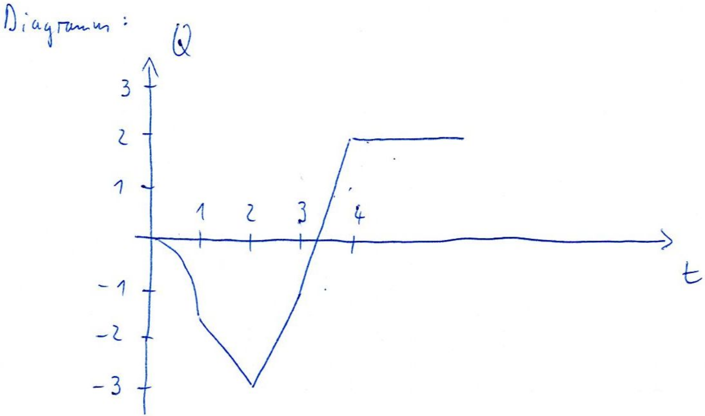
Ladung: $Q(t) = \int_0^t i(t)\,dt + Q(0)$

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

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

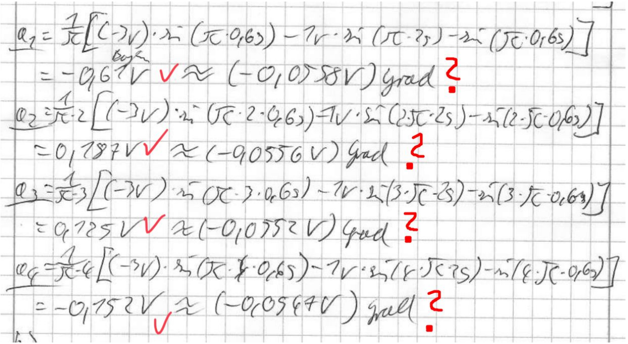
$Q(1s) = -1{,}5$

Free Handwritten Solution



Examples of Student Misconceptions

Specification of Fourier coefficients in V and V °:



$a_1 = \frac{1}{\pi}\left[(-3V)\cdot\sin(\pi\cdot 0{,}6s) - 1V\cdot\sin(\pi\cdot 2s) - \sin(\pi\cdot 0{,}6s)\right]$

Bogen

$= -0{,}617V$ ✓ $\approx (-0{,}0558V)$ grad ?

$a_2 = \frac{1}{\pi\cdot 2}\left[(-3V)\cdot\sin(\pi\cdot 2\cdot 0{,}6s) - 1V\cdot\sin(2\pi\cdot 2s) - \sin(2\cdot\pi\cdot 0{,}6s)\right]$

$= 0{,}187V$ ✓ $\approx (-0{,}0556V)$ Grad ?

$a_3 = \frac{1}{\pi\cdot 3}\left[(-3V)\cdot\sin(\pi\cdot 3\cdot 0{,}6s) - 1V\cdot\sin(3\cdot\pi\cdot 2s) - \sin(3\cdot\pi\cdot 0{,}6s)\right]$

$= 0{,}125V$ ✓ $\approx (-0{,}0552V)$ Grad ?

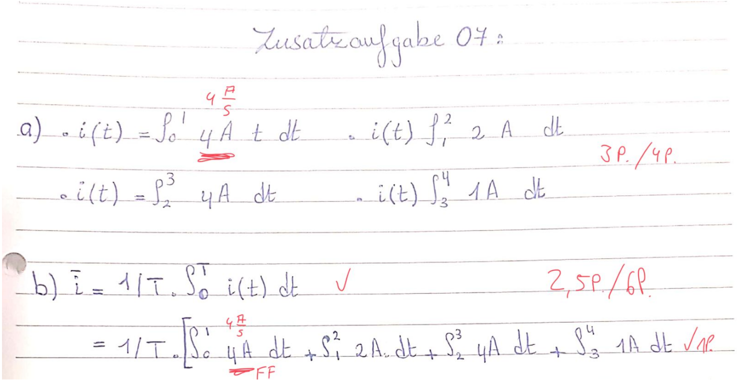
$a_4 = \frac{1}{\pi\cdot 4}\left[(-3V)\cdot\sin(\pi\cdot 4\cdot 0{,}6s) - 1V\cdot\sin(4\cdot\pi\cdot 2s) - \sin(4\cdot\pi\cdot 0{,}6s)\right]$

$= -0{,}152V$ ✓ $\approx (-0{,}0547V)$ Grad ?

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

Examples of Student Misconceptions

Specifying the time function directly with an integral:



Zusatzaufgabe 07:

a) • $i(t) = \int_0^1 \overset{4\frac{A}{s}}{4A}\, t\, dt$ • $i(t) \int_1^2 2\,A\, dt$

3P./4P.

• $i(t) = \int_2^3 4A\, dt$ • $i(t) \int_3^4 1\,A\, dt$

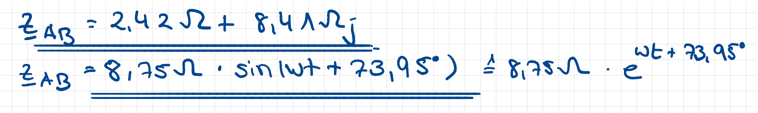
b) $\bar{I} = 1/T \cdot \int_0^T i(t)\, dt$ ✓ 2,5P./6P.

$= 1/T \cdot \Big[\int_0^1 \overset{4\frac{A}{s}}{4A}\, dt + \int_1^2 2A \cdot dt + \int_2^3 4A\, dt + \int_3^4 1A\, dt$ ✓/1P.

FF

Examples of Student Misconceptions

Complex impedance converted to time function:



$$\underline{\underline{\underline{Z}_{AB} = 2,42\,\Omega + 8,41\,\Omega j}}$$

$$\underline{Z}_{AB} = \underline{\underline{8,75\,\Omega \cdot \sin(\omega t + 73,95^\circ)}} \mathrel{\hat{=}} 8,75\,\Omega \cdot e^{\omega t + 73,95^\circ}$$

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

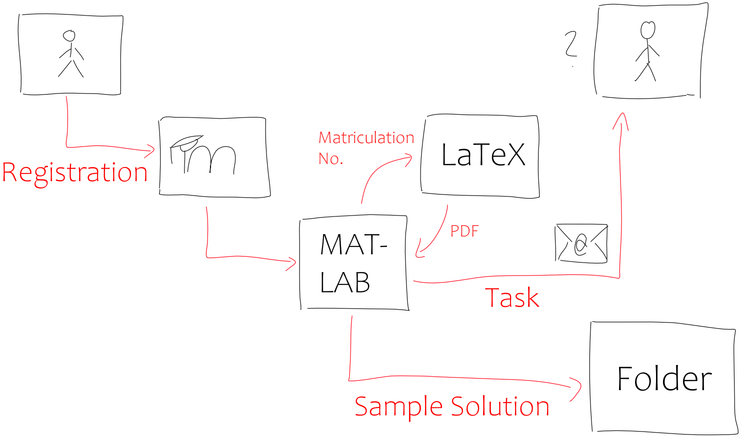
Idea

Personalizable tasks for handwritten solution:

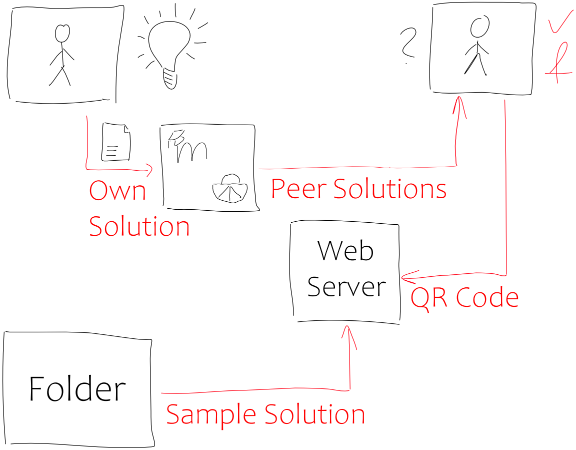
- handwritten ⟶ authentic, low-threshold for formulas, schematics, diagrams, misconceptions become visible
- personalized ⟶ no plagiarism possible
- peer review ⟶ no correction effort ⟶ good ready-made personalized sample solution
- via Moodle, Feedback Fruits and e-mail ⟶ scalable, no „red tape“

How does it work?

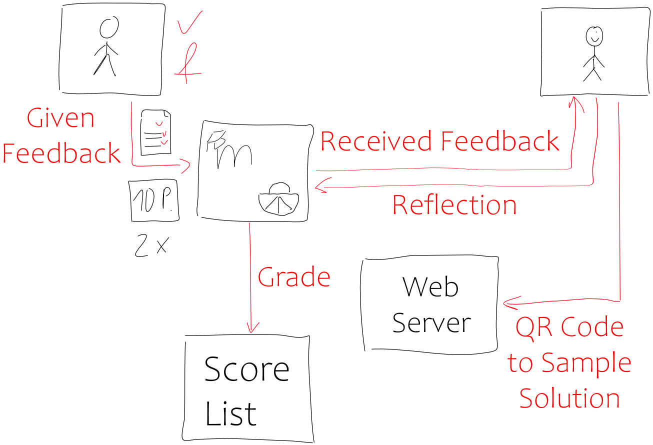
Creation and Sending of the Tasks



Submission and Distribution of the Solutions



Mutual Correction and Completion



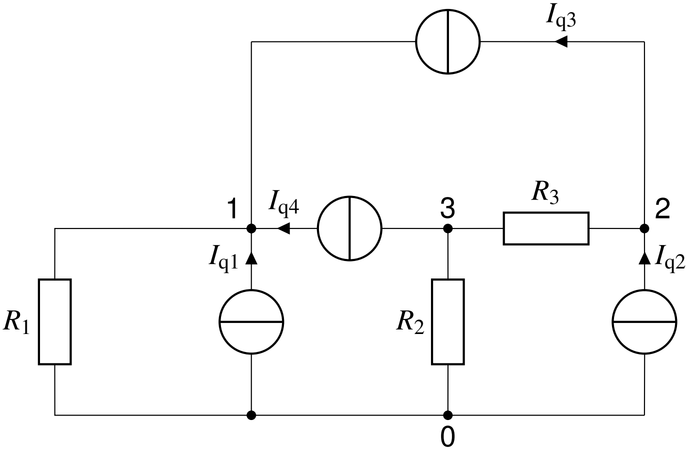
What does a typical task look like?

Task (Same for all)

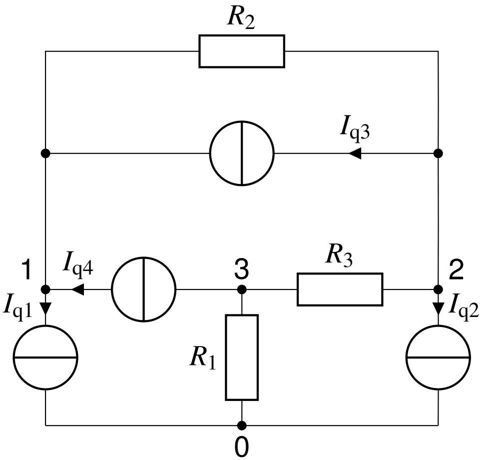
Nodal analysis shall be used to calculate the three nodal voltages U_{Kn1}, U_{Kn2} and U_{Kn3} between the respective node and the reference node.

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).

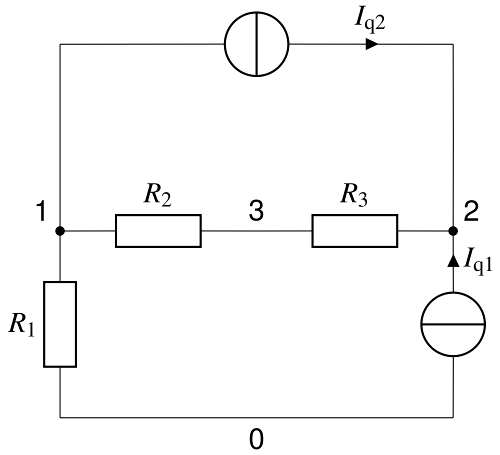
Circuit Diagram (for Matriculation Number $123\,460$)



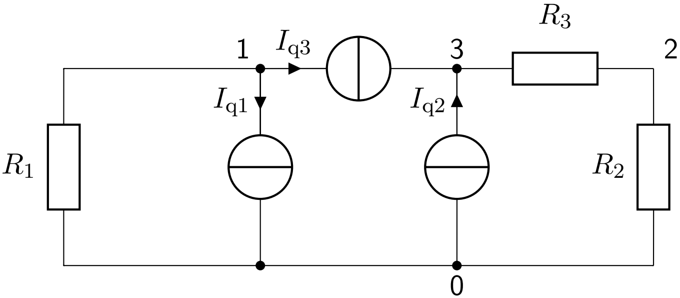
Circuit Diagram (for Matriculation Number 123 461)



Circuit Diagram (for Matriculation Number 123 462)



Circuit Diagram (for Matriculation Number 123 463)



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:

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

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:

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

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:

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

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:

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

Implementation in MATLAB

How to Import Student Data?

Table data:

```
no,first,family,email,register,course
1,Bosco,Baracus,b.a.@a-team.org,123456,Mechatronics (Bachelor)
2,Tempelton,Peck,face@a-team.org,234567,Textile Design (Master)
3,John,Smith,hannibal@a-team.org,345678,Management (Master)
4,H.M.,Murdock,murdock@a-team.org,456789,Aeronautics (Bachelor)
```

How to Generate and Compile LaTeX Documents?

Relevant commands:

```
rng(register+salt);
resistor=randi(10);
fid=fopen(latex_filename,'w');
fprintf(fid,'%s\n','\begin{equation}');
fprintf(fid,'%s\n','<more LaTeX code>');
fclose(fid);
dos('pdflatex main_latex_filename');
matlabmail(email,message,subject,filename);
```

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matlabmail(email,message,subject,filename);
```

⟶ repeated inside a loop for every student

How to Send Messages from MATLAB?

```
MATLABMAIL( recipient, message, subject )

sends the character string stored in 'message' with subject
'subject' to the address in 'recipient', from the email
address stored in the file. This requires that the
sending address is a GMAIL email account.
```

Source: D. Gleich, „Get Matlab to email you when it's done running!“ (Feb. 2014), [Online]. Available: `https://dgleich.wordpress.com/2014/02/27/get-matlab-to-email-you-when-its-done-running/`

What came out of it?

Evaluation of a Typical Cycle

Bare numbers:

- Tasks sent to about 200 students
- Solutions submitted by about 100 students
- Review carried out by about 90 students

Evaluation of a Typical Cycle

Bare numbers:

- Tasks sent to about 200 students
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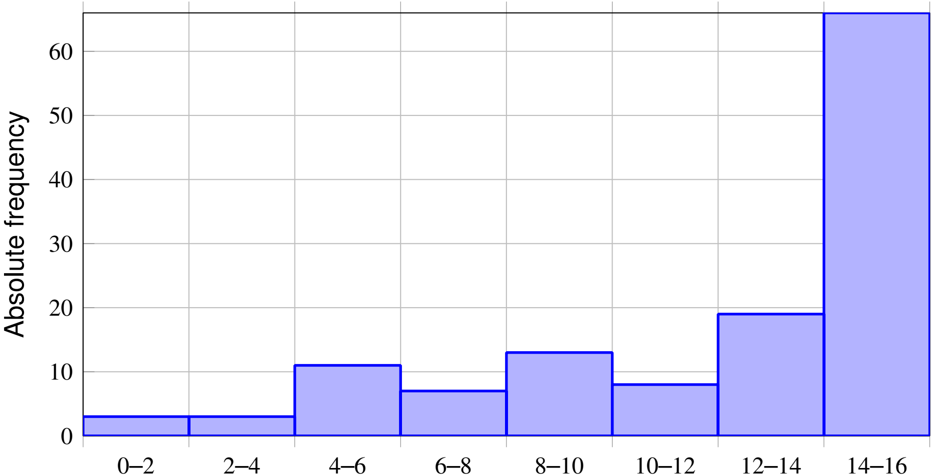
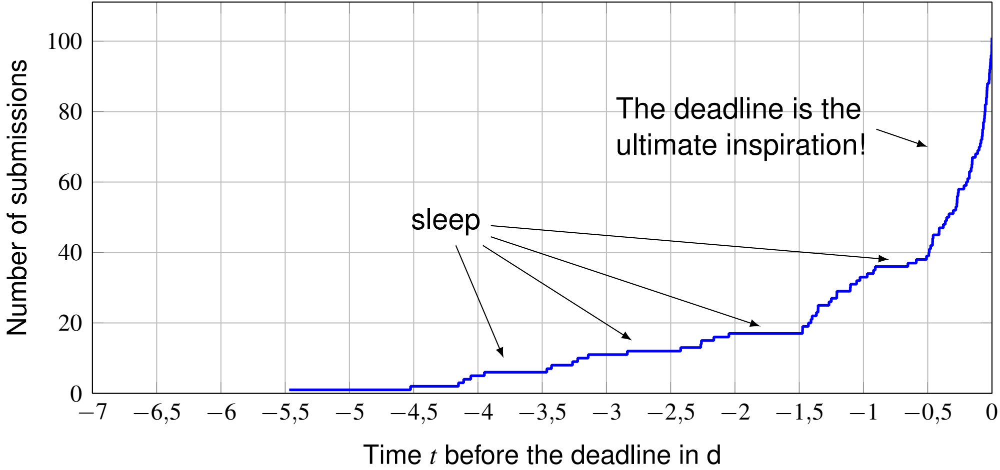
Advantage:

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

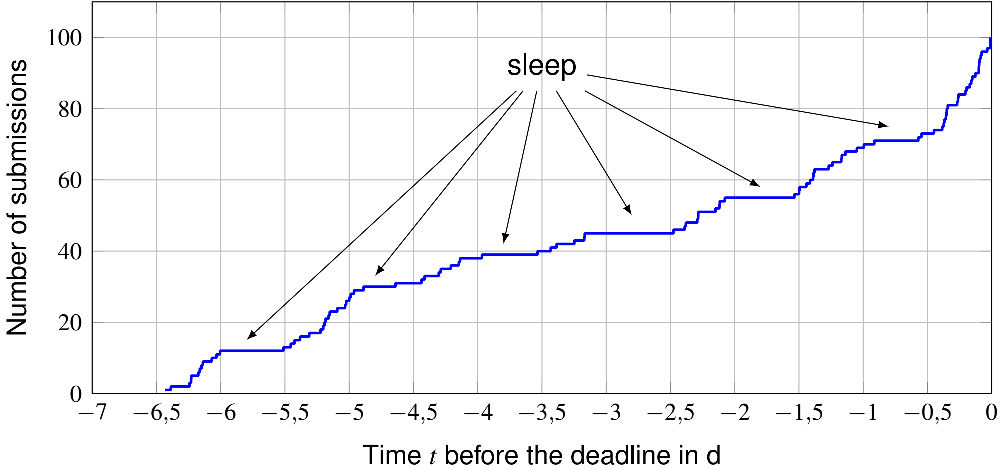
Typical Distribution of the Points



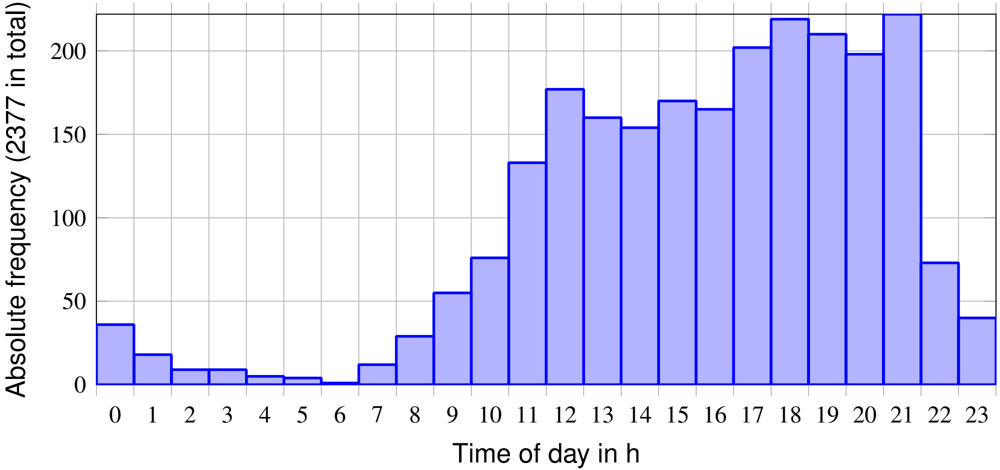
Typical Timing of Submission



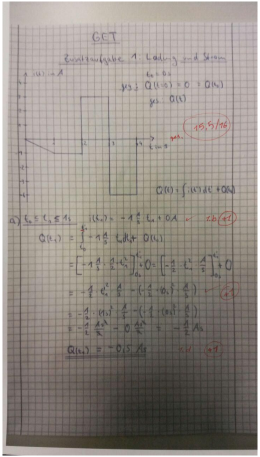
Typical Timing of Peer Reviews

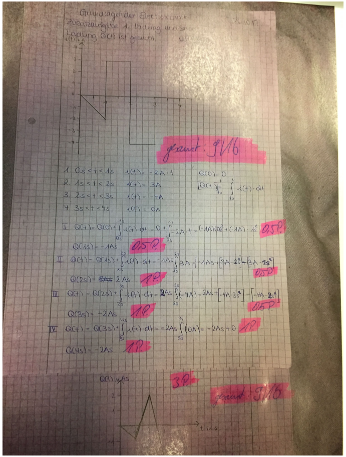


When Do Students Submit?



Remaining Problem: Poor Image Quality of Submissions/Corrections





Further Information

Achievements to date:

- 13 different task types developed so far
- 64 runs in 14 semesters so far
    - 13 000 personalized tasks sent out
    - 5500 student solutions submitted
    - 10 000 student peer reviews accomplished

Links (in German):

Lightning Talk:	`https://youtu.be/LDw_Ifmg2WM`
Twitter:	`#PersonalisierteAufgaben`
Article:	Research in Learning Technology, DOI: 10.25304/rlt.v28.2339
FAQ:	SlideShare

https://twitter.com/MarkusRidderbu8/status/
1523708966039351297

Thank you very much for your attention!

Are there any questions?