Basics of TUMexam

Exam:	IN0000 / Endterm	**Date:**	Friday 1st February, 2019
Examiner:	Prof. Dr.-Ing. Georg Carle	**Time:**	13:00 – 14:00

	P 1	P 2	P 3	P 4	P 5	P 6
I						

Working instructions

- This exam consists of **16 pages** with a total of **6 problems**.
  Please make sure now that you received a complete copy of the exam.

- The total amount of achievable credits in this exam is 76 credits.

- Detaching pages from the exam is prohibited.

- Allowed resources:

  - one **non-programmable pocket calculator**

  - one **analog dictionary** English ↔ native language

- Subproblems marked by * can be solved without results of previous subproblems.

- **Answers are only accepted if the solution approach is documented.** Give a reason for each answer unless explicitly stated otherwise in the respective subproblem.

- Do not write with red or green colors nor use pencils.

- Physically turn off all electronic devices, put them into your bag and close the bag.

Left room from _____ to _____	/	Early submission at _____

Problem 1   Configuration (25 credits)

The general configuration for an exam is made in the file `conf/examconf.tex`. Various exam-specific parameters which are described in the following have to be set there.

0
1

a) Specify the title of your exam. That commonly refers to the lecture to which the exam belongs.

0
1

b) Specify the type of your exam, e. g. Endterm, Retake, Modulprüfung.

0
1

c) Set your module number, normally a code consisting of two letters and four to five digits.

0
1

d) Specify the date of your exam (day, month, year).

0
1

e) Specify the begin and end times of your exam.

0
1

f) Choose the language (`english` or `german`).

0
1

g) Set your organization with the corresponding acronym as defined in `tumcommon/tumlang.sty`.

0
1

h) Set the examiner (you can use `\chairhead` if that is the examiner).

i) State if you want to have one or two correction passes
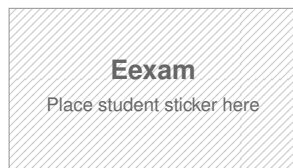
☐ \singlepasstrue (one correction pass)

☐ \singlepassfalse (two correction passes)

j) State if you want to give half credits.

☐ \halfcreditstrue

☐ \halfcreditsfalse

k) Registration stickers vs. registration boxes:

Eexam
Place student sticker here

☐ \registrationstickerfalse (no stickers but boxes)

☐ \registrationstickertrue (stickers)

Everyone who has used TUMexam once knows about the manual task of preparing the attendee lists with registration stickers. Of course, TUmexam also supports registration boxes as alternative. However, we urge you to use the registration stickers whenever possible. The reasons are:

1. It seems to be a tough task for our students to correctly mark their registration number in the box.

2. If 5 % of your students do not get their registration number correctly marked, and you have 1000 participants, do the math of manually fixing registration numbers.

3. Of course, that is only a hassle, provided that students follow requests and write their registration number as digits in the headline of the box (and if they do, given that you can read it . . .).

4. However, most important, a student might accidentally hit the registration number of another student that is registered to the exam but does not show up. That case cannot be detected and the the exam is assigned to the wrong student!

Registration stickers are virtually fail-proof. So it is up to you whether you want peace of mind at cost of some time or you rather want the quickest way of creating attendee lists and accept the possibility of undetectable errors.

l) If you want to create your problem sheet separate from the answer sheet, then you may need this option. Seperate answer sheets may ease your decision regarding the online exam review as the problems are not made available to students after the exam, only their answers. Please contact us for details.

☐ \externalproblemsfalse

☐ \externalproblemstrue

m) State if you want an additional cover sheet. We discourage the use as it increases the print times due to the additional envelope per exam.

☐ \coversheetfalse

☐ \coversheettrue

n) Specify how your exam should be printed and stapled.

☐ \booklet (a booklet)

☐ \onestaple (one staple at the top left corner)

☐ \nostaple (only useful if there is only one sheet)

o) Specify if you want serif font or the TUM corporate design font Helvetica.

☐ \seriftrue

☐ \seriffalse

p) Specify if you want arabic numbering of subproblems.

☐ \subproblemarabicfalse

☐ \subproblemarabictrue

q) Do not show the amount of credits per problem.

☐ \noproblemcreditsfalse

☐ \noproblemcreditstrue

r) Remove the problem heading. This option is useful only if your exam consists of a single problem with multiple subproblems, e. g. quizze and surveys.

☐ \noproblemfalse

☐ \noproblemtrue

s) Remove the title section from the first page. This option is useful for very compact exams, quizze, or surveys.

☐ \notitletrue

☐ \notitlefalse

t) The title page of an exam has a rectangular corrector box per problem and per correction pass. It is meant solely as a signature field for correctors to indicate whether or not and by whom a specific problem has been corrected. If you do not want those boxes for some reason, e. g. you have so many problems that the boxes do not fit into a single line, you may remove them using this option.

☐ \nocorrectorboxtrue

☐ \nocorrectorboxfalse

u) Enable if you want to print single-sided exams. This may be usefull if in combination with the `\onestaple` option. The backsides will still have pagecodes, which is important for scanning as we cannot prevent students from writing something on the backsides. Do **not** use this option together with `\coversheettrue`.

☐ `\singlesidetrue`

☐ `\singlesidefalse`

Some texts can be modified as follows.

v) Allowed tools

☐ 0

☐ 1

w) Announcement of tools

☐ 0

☐ 1

x) Notes on the exam title page

☐ 0

☐ 1

y) Notes on the binder

☐ 0

☐ 1

Problem 2 Building (10 credits)

The template depends on an up to date version of texlive-full and GNU make to build everything you need for your exam. Please note that using an IDE for LaTeX documents such as TeXstudio is not explicitly supported, but possible for the most part if you correctly setup the directories from which class and style files are loaded.

The first part of make commands is used during exam creation, i. e., before building the final exam copies, attendee lists, seatplans, and protocols.

Hint: For answers to the following questions, build a solution with correction notes of this exam using `make correction`.

0 ☐
1 ☐
a) How is the exam itself built?

0 ☐
1 ☐
b) How is the solution built?

0 ☐
1 ☐
c) How is the annotated solution containing all correction notes built?

0 ☐
1 ☐
d) How is an example exam with page codes as it is printed built?

0 ☐
1 ☐
e) How is a side by side version of the exam and the annotated solution built?

0 ☐
1 ☐
f) How are all of the above documents built?

The second part of make commands is used to create the documents for printing.

g) How are all of the individual exams built?
Hint: EXAMCOUNT is set to the number of copies required.

☐ 0
☐ 1

h) How are all of protocol, attendeelist, etc. built?

☐ 0
☐ 1

i) How is all the remaining metadata that is needed for scanning built?

☐ 0
☐ 1

j) How can we speed up the building of exams?

☐ 0
☐ 1

Problem 3 Some background on how TUMexam works (14 credits)

In the following we discuss some more background regarding the TUMexam LATEX template. This understanding will prevent you from some pitfalls that users sometimes encounter.

a)* The instruction box below contains a page code which is typeset three times on every page of a printable exam copy. Which information is contained in such a code?

IN-BT-1-20200101-E0001-01

b)* Is it neccessary that all page codes can be read.

c)* What happens if an ERID is printed twice?

d)* Can additional pages, e. g. scratch paper, be added to an exam?

☐ 0
☐ 1
☐ 2

e)* The first page of a printable exam copy (one with page codes) contains a box named "Exam empty" in the footline, all other pages have a box named "Page empty". What are these boxes used for?

☐ 0
☐ 1
☐ 2

Problem 4 Creating problems (10 credits)

This section describes how the problems of an exam are created. It is advisable to not only read this document, but also have a look at the source code of the sample problems.

Hint: Problems that can be solved without solving previous subproblems first are marked by *. (It is up to you whether or not you want to tell that your students, but if you do, please do it carefully.)

0
1
a)* First, we need to declare a problem.

0
1
b) Then, we need to declare the subproblems.

There are different environments to create solutionboxes.

0
1
c) How can we define a normal solutionbox of 3 cm in height?

0
1
d) How can we annotate the solution with correction notes?

0
1
e) How can we define a solutionbox with instructions?

```
\begin{instructionbox}
This is instructiontext, e.\g. a table preprint
\solution{


}
\end{instructionbox}
```

f) How can we define a solutionbox with gridlines?

g) How can we define a solutionbox with grid and instructions?

```
\begin{gridinstructionbox}
This is instructiontext, e.\g. a table preprint
\solution{


}
\end{gridinstructionbox}
```

h) How can we define a multiple choice question?

Mark correct answers with a cross ☒

To undo a cross, completely fill out the answer option ■

To re-mark an option, use a human-readable marking ☓■

☐ \subproblem[strict_multiple_choice]{1}

☐ \subproblem[binary_multiple_choice]{1}

☐ \subproblem{1}

Please contact us if you want to use multiple choice questions as there are some details to be clarified regarding how MC questions should be evaluated by TUMexam.

i)* TUMexam allows to pass a seed value for pgfmath's pseudo random number generator via jobnames. If no jobname is supplied or the jobname is not an integer, we use the magic number 42 for initialization. That allows for deterministic sample solutions but randomized problems for students.

```
1,2,3,4
2,3,4,1
3,4,1,2
4,1,3,2
1,3,2,4
2,4,3,1
```

j)* „Ich bitte Sie, das neue Corporate Design konsequent umzusetzen. Sehen Sie darin eine Loyalitätspflicht der Hochschulmitglieder, damit sich der Hinweis auf die Rechtsverbindlichkeit erübrigen kann."[1]

For that reason, TUMexam is based on Helvetica, and we do our best to convince you of Helvetica–even in math mode:

mathnormal	$abcdefghhjkklmnopqrstuvwxyz$
	$ABCDEFGHJKLMNOPQRSTUVWXYZ$
	1234567890
	$\alpha\beta\gamma\delta\epsilon\zeta\eta\theta\kappa\lambda\mu\nu\xi\pi\rho\sigma\tau\phi\chi\psi\omega$
	$\Delta\Theta\Lambda\Pi\Phi\Psi\Omega$
mathbit	$\boldsymbol{abcdefghjklmnopqrstuvwxyz}$
	$\boldsymbol{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$
	$\boldsymbol{01234567890}$
	$\boldsymbol{\alpha\beta\gamma\delta\epsilon\zeta\eta\theta\kappa\lambda\mu\nu\xi\pi\rho\sigma\tau\phi\chi\psi\omega}$
	$\boldsymbol{\Delta\Theta\Lambda\Pi\Phi\Psi\Omega}$
mathcal	$\mathcal{ABCDEFGHIJKLMNOPQRSTUVXYZ}$
symbols	$\displaystyle\sum_{n=1}^{N}\frac{N(N-1)}{2},\quad \frac{1}{2\pi}\int_{-\infty}^{\infty}f(x)e^{-j\omega t}\,\mathrm{d}t$
addons	$\Pr\left[X=x \mid Y=y\right],\operatorname{Var}[x],\operatorname{E}[X]$

If you plan to disobey this request, you may use computer modern instead by setting `\seriftrue` in `examconf.tex`.

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[1] Wolfgang A. Herrmann, Corporate Design Handbuch 2016

Problem 5 Single stream point-to-point MIMO on multiple carriers (4 credits)

We consider the communication scenario in Figure 5.1 where multiple data streams s_k are transmitted on K subcarriers, one stream per carrier. The signals s_k are mutually independent and Gaussian distributed with zero mean and unit variance, i. e., $s_k \sim \mathcal{N}_{\mathbb{C}}(0, 1)$. The transmitter and receiver have N and M antennas, respectively. The signal s_k denotes the data stream transmitted on carrier k which is precoded with $\boldsymbol{p}_k \in \mathbb{C}^N$
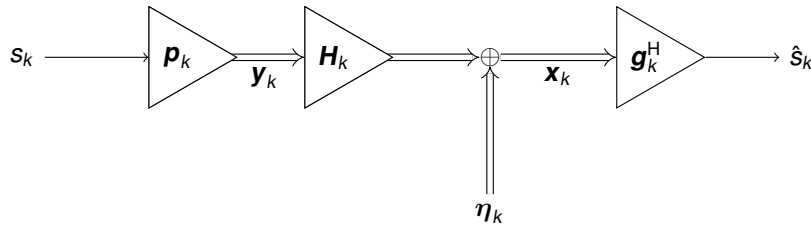

Figure 5.1: Single-stream point-to-point MIMO

and transmitted via the channel $\boldsymbol{H}_k \in \mathbb{C}^{M \times N}$.

The received signal $\boldsymbol{x}_k \in \mathbb{C}^M$ is perturbed with Gaussian noise $\boldsymbol{\eta}_k \sim \mathcal{N}_{\mathbb{C}}(\boldsymbol{0}_M, \boldsymbol{C}_k)$ with noise covariance $\boldsymbol{C}_k \in \mathbb{C}^{M \times M}$. Filtering with the receive filter $\boldsymbol{g}_k \in \mathbb{C}^M$ yields the received signal $\hat{s}_k$. The sum transmit power across all carriers is bounded by

$$\sum_{k=1}^{K} \mathsf{E}\left[\|\boldsymbol{y}_k\|_2^2\right] \leq E_{\mathsf{Tx}}. \tag{1}$$

In the first part of this problem we will consider above system without equalizer.

a)* Give an expression for $\boldsymbol{x}_k$ as a function of s_k and $\boldsymbol{\eta}_k$.

b)* Rewrite the power constraint (1) as a function of $\boldsymbol{p}_k$.

c) Calculate the covariance matrix $\boldsymbol{C}_{\boldsymbol{x}_k}$ of the received signal $\boldsymbol{x}_k$.

Problem 6 Finite extension fields (13 credits)

Given the finite filed $\mathbb{F}_p$, we consider finite extension fields

$$F_q[x] = \left\{ \sum_{i=0}^{n-1} a_i x^i \;\middle|\; a_i \in \mathbb{F}_p \right\}. \tag{2}$$

0
1

a)* State the conditions on p, q, and n such that a finite extension field $F_q[x]$ exists.

0
1

b)* What is a *generator* of $\mathbb{F}_p$?

We now consider the finite extension field $F_{16}[x]$ built upon $\mathbb{F}_2 = \{0, 1\}$.

0
1
2

c)* State two reasons why this extensions field is of particular interest with respect to network coding.

0
1
2

d)* List all elements of $F_{16}[x]$.

e)* Explain why a reduction polynomial $r(x)$ is needed for the multiplicative group of $F_q[x]$.

f) State the conditions a polyomial $r(x)$ has to fulfill to be a suitable reduction polyomial.

g) Find a reduction polynomial $r(x) \neq x^4 + 1$ for $F_q[x]$.

Additional space for solutions–clearly mark the (sub)problem your answers are related to and strike out invalid solutions.