Analysis, Design and Modeling of the Wastewater Treatment Plant St. Gallen Hofen

Master Project Fall Semester 2015

Head: Prof. Dr. Eberhard Morgenroth
Advisor: Jonas Eppler

Documentation

Areal image of the WWTP Hofen (SWISSIMAGE, 2015)
Source for image on the title page:

Imprint:
Chairs of Urban Water Management
Assistants’ Office, HIL G31.2
ETH Zurich
Tel. +41 44 633 70 92
Email: eppler@ifu.baug.ethz.ch
## Index

1. **DATES** ........................................................................................................... 1

2. **AIMS** ............................................................................................................ 2

3. **BACKGROUND** ............................................................................................ 3

4. **TASK DEFINITION** ....................................................................................... 5
   - 4.1 **Phase 1: Assessment of the Current Plant** .............................................. 5
   - 4.1.1 Data analysis ............................................................................................... 5
   - 4.1.2 Onsite-Experiments and Modelling ........................................................ 5
   - 4.2 **Phase 2: Design and Assessment of a Future Plant** ............................... 6
   - 4.2.1 Boundary conditions .................................................................................. 6
   - 4.2.2 Evaluation criteria ....................................................................................... 6
   - 4.2.3 Design loads ................................................................................................. 6
   - 4.2.4 Design of a new nutrient removal system .................................................. 6
   - 4.2.5 Modeling and assessment of the proposed plant design ............................ 6
   - 4.3 **Phase 3: Synthesis** .................................................................................... 6

5. **ORGANIZATION** ............................................................................................ 7
   - 5.1 **Supervision** ............................................................................................... 7
   - 5.2 **Intermediate Meetings** ............................................................................. 7
   - 5.3 **Submitted Results** .................................................................................... 7
   - 5.4 **Evaluation** .................................................................................................. 7
   - 5.5 **Office Hours** .............................................................................................. 8
   - 5.6 **Tools, Documentation** ............................................................................... 8
   - 5.7 **Working Place** ........................................................................................... 8
   - 5.7.1 General rules ............................................................................................... 8
   - 5.7.2 Login ............................................................................................................ 9
   - 5.7.3 Data protection ............................................................................................ 9

6. **REFERENCES** .................................................................................................. 11

7. **ANNEX** .......................................................................................................... 13
   - 7.1 **Criteria for the Evaluation of the Master Project** .................................... 13
1 Dates

The beginning of the Master project should be coordinated with the supervisor and the professor. The submission date is fixed by the secretariat of the Institute of Environmental Engineering (S. Schirrmacher) and the project has to be finished within 7 weeks.

The dates for the intermediate review questions and the final presentation of the project work are listed here. Depending on the weather, changes can still take place. This would be communicated by the assistants.

<table>
<thead>
<tr>
<th>Event</th>
<th>Day</th>
<th>Date</th>
<th>Time</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>Wednesday</td>
<td>16.9.</td>
<td>13:00 – 14:00</td>
<td>HIL G 36.1</td>
</tr>
<tr>
<td>WWTP ARA St. Gallen Hofen</td>
<td>Monday</td>
<td>21.9.</td>
<td>All day</td>
<td>WWTP Hofen in Wittenbach (Arboner Strasse 42, 9300 Wittenbach)</td>
</tr>
<tr>
<td>1st Intermediate Meeting</td>
<td>Wednesday</td>
<td>7.10.</td>
<td>14:00 – 15:30</td>
<td>Meeting room, Kuster + Hager in St. Gallen (Oberstrasse 222, 9014 St. Gallen)</td>
</tr>
<tr>
<td>2nd Intermediate Meeting</td>
<td>Wednesday</td>
<td>21.10.</td>
<td>14:00 – 15:00</td>
<td>HIL G 36.1</td>
</tr>
<tr>
<td>Final Presentation</td>
<td>Thursday</td>
<td>29.10.</td>
<td>09:00 – 09:50</td>
<td>HIL G 36.1</td>
</tr>
<tr>
<td>Final Apéro</td>
<td>Thursday</td>
<td>29.10.</td>
<td>11:00 – 12:00</td>
<td>HIL G 36.1</td>
</tr>
<tr>
<td>Submission Report</td>
<td>Wednesday</td>
<td>4.11.</td>
<td>16:00</td>
<td>HIL G 31.2</td>
</tr>
</tbody>
</table>
2 Aims

After the 2nd semester of the Master studies, the lectures are completed and students should have acquired skills and tools necessary for their profession. The Master project work offers a first opportunity to apply and adapt the knowledge in the different phases of a project.

It is the aim of the Master project to find independent and professional answers to actual real-world problems and to present the obtained solutions in a professional manner. Students must be able to understand, analyze, and solve a problem with the proper tools. They must know how to deal with a large quantity of data, as this is the basis of most projects.

The goals for the Master project are as follows:

*Content of the work:*  
- Work with an incomplete, missing or inaccurate data basis  
- In-depth insight into the process of urban water management  
- Application of tools as demonstrated in the lectures  
- Assessment of limits and uncertainties of suggested predictions

*Formal requirements:*  
- Project- and team work  
- Practice oral and written presentations  
- Handling of professional literature and engineering reports  
- Evaluating, reasoning, and „selling“ of results  
- Communication with lecturers, engineers, operating personnel, and politicians  
- Get to know your own limits (time pressure and uncertainties)

It is important to work professionally throughout the entire project. Keep records of your ideas and project steps. Prepare a time-schedule of intermediate goals. Check your schedule regularly and revise your planning if necessary. Reserve yourself enough time for the final presentation and the technical report. Begin in good time with the writing of the different chapters. The results of your work are definite, can be passed on, and may serve a third party as a basis for another decision.
3 Background

The city of St. Gallen is in the catchment of the Lake of Constance. This lake borders Austria, Germany and Switzerland. Its ecosystem and those downstream are sensitive to water discharges upstream. Hence, the agreement for the protection of the Lake of Constance was set up (IGKB, 2005). In addition to the aforementioned agreement, the Swiss Waters Protection Ordinance (GSchV, 1998) is also applicable. The water quality requirements for the lake are stringent\(^1\). This also concerns the effluent requirements of wastewater treatment plants (WWTP) in its catchment.

The Wastewater Treatment Plant (WWTP) St. Gallen Hofen in the canton of St. Gallen is one of those WWTPs\(^2\). At present, its effluent requirements are exceeded for a selection of effluent parameters (Entsorgung St. Gallen, 2014a). Hence, a project has been put into motion to improves its biological treatment step. Currently, the project team (consisting of the operator, engineers and the responsible public authorities) is planning the design of a future WWTP with an expanded treatment capacity to account for expected population growth\(^3\) and to possibly include an improved biological treatment with a denitrification step. The future WWTP will be subject to these boundary conditions:

- **Spatial**: The first boundary condition is given by the spatial constraints (see Figure 1).
- **Temporal**: The second is temporal and given by the operation of the future plant between the proposed operating duration 2020-2050.
- **Catchment development**: Assume growth in population equivalents based on population estimations and seek modular, upgradeable solutions.
- **Effluent requirements**: The agreement for the protection of the Lake of Constance sets (IGKB, 2005) and the Swiss Waters Protection Ordinance (GSchV, 1998) are valid.

Currently, three different treatment systems are in discussion for the future WWTP: An activated sludge system (e.g. using a modified Ludzack-Ettinger process), a moving bed biofilm reactor (MBBR) or a fixed bed biofilm reactor.

The overall goal of the current Master project is to develop recommendations for the operation of the current wastewater treatment plant and the construction and operation of a future wastewater treatment plant taking into account the aforementioned boundary conditions.

\(^1\) [http://www.gaa.baden-wuerttemberg.de/servlet/is/19586/4_3_02.pdf](http://www.gaa.baden-wuerttemberg.de/servlet/is/19586/4_3_02.pdf) (last downloaded on the 14th of September 2015)


\(^3\) [www.statistik.sg.ch](http://www.statistik.sg.ch) (last downloaded on the 15th of September 2015)
Figure 1: Areal image of the WWTP Hofen with the spatial boundary for the expansion of the existing biological treatment reactors in red (SWISSIMAGE, 2015)
4 Task Definition

4.1 Phase 1: Assessment of the Current Plant

In this phase, the current state of the biological treatment will be analyzed. Data analysis and experiments of the first phase will focus on current issues of the plant. The specific goals are to identify and characterize deficits in the current design or operation of the plant regarding aforementioned factors. These deficits will serve as a basis for proposed measures in the second phase of this project.

4.1.1 Data analysis

In this step, you should gain a general impression of the issues concerning the biological treatment step of the WWTP Hofen. Be sure to perform your data analysis in steps to ensure correct data interpretation:

1. **Removal of incorrect or missing data:** If necessary, identify and remove missing or incorrect data which are either out of range, display an unusual dynamic or are not consistent with expectations based on redundant data (e.g. \([\text{NH}_4^+] > \text{[TN]}\)).

2. **Visualization:** Visualize the dynamic patterns of the wastewater constituents and nutrient removal efficiencies. You may use a preconfigured version of SeNARA or any other visualization and data manipulation tool (e.g. R, MATLAB) for this purpose.

3. **Assessment:** Assess and substantiate the key deficits concerning the nutrient removal efficiencies. Focus on the most important chemical species (e.g. BOD, TP, \(\text{NH}_4^+\), \(\text{NO}_3^-\), \(\text{NO}_2^-\)) for which the Swiss Waters Protection Ordinance (GSchV, 1998) and the Lake Constance Agreement (2005) define effluent requirements.

4.1.2 Onsite-Experiments and Modelling

One experiment will be performed on site: Measurements of the gas concentration and the gas flow rate in the aeration tank 2.1. The interesting quantity that can thereby be calculated is the actual oxygen transfer rate (AOTR) in g\(\text{O}_2\)/h and the oxygen transfer efficiency (OTE) in %. Both quantities can be compared to expected and optimal values known from literature data. Two types of variations should be analyzed:

- Temporal variation (e.g. across a day)
- Spatial variation (e.g. along the length of an aeration tank or – if the time budget allows for such measurements - across different aeration reactors [with or without separation baffles])

Explain the differences between the standard and the actual OTR and OTE values across time and space. In addition, derive recommended short-term operational measures based on the data analysis and the onsite experiments.
4.2 Phase 2: Design and Assessment of a Future Plant

The biological treatment should include a nitrification and a denitrification step. In addition, the aeration blowers will be driven by turbo blowers (Kuster + Hager AG, 2015).

4.2.1 Boundary conditions

The boundary conditions have already been mentioned in the previous section on the background.

4.2.2 Evaluation criteria

You will define an approach to evaluate the performance of your biological treatment based on predefined criteria. The evaluation criteria should include nutrient removal.

4.2.3 Design loads

You will analyze and characterize the new plant based on the relevant parameters identified as problematic in the first phase (e.g. COD, N or P). Calculate design loads based on past process data and consider relevant safety factors.

4.2.4 Design of a new nutrient removal system

An upgraded biological treatment is currently in the planning phase for the new WWTP St. Gallen Hofen. Provisions are made for a replacement of the blowers to energy efficient turbo blowers (Kuster + Hager AG, 2015). Design an activated sludge system with denitrification (e.g. a Ludzack-Ettinger process). The design should consider the boundary conditions, evaluation criteria and design loads derived in the previous steps. Assess the designed biological treatment step qualitatively and quantitatively (see following section).

4.2.5 Modeling and assessment of the proposed plant design

Model the biological treatment system with the software ASIM. First, model the steady state of the system and assess the plant using your evaluation criteria. Second, model your proposed plant design with variable seasonal loading and assess the robustness of your plant using your evaluation criteria. Optimize the treatment quality of the plant iteratively. Consider the good modeling practices presented during by Prof. Morgenroth during the first intermediate meeting (Rieger, 2013).

4.3 Phase 3: Synthesis

This last phase addresses the interests of the engineering firm as well as of the operator of the WWTP in the form of concrete recommendations. The engineering firm is interested in inputs regarding the design and operation of the future plant. The operator is interested in inputs regarding the operation of the current plant. Adapt and formulate your recommendations accordingly.
5 Organization

5.1 Supervision

The project will be supervised by the assistants and is in charge of Prof. E. Morgenroth. Any other supervision must be agreed upon by Prof. Morgenroth and the assistants.

5.2 Intermediate Meetings

During the Master project there will be two intermediate meetings of each 50 minutes. In the first <25 minutes students present their intermediate results (short lecture, overhead projector und a board are at disposal) and outline their procedure up to that stage. In the following half an hour pending questions will be discussed with the supervisors.

Intermediate meetings will not be graded. However, the presentation can be shortly discussed if a student wishes so (This must be agreed upon with the assistants, before the presentation!).

It is important to have your questions to the Master project properly prepared so that you can benefit by the expert knowledge of all present.

5.3 Submitted Results

Report (max. 25 p)

Submission of reports at the assistants' office is on the last day of the planning schedule, by 16:00 at the latest. It includes:

- Two paper copies of the report (incl. Annex). Printing costs of one copy are paid by the students themselves. Further required copies will be paid by the chair, upon presentation of the receipt for printing costs. If the Master project was developed in cooperation with several external partners (i.e., community, engineering office, Eawag) then more copies are to be printed.
- A CD-ROM with all data (report, incl. annex in PDF-format, models, data, etc.)

The form, Statement regarding plagiarism when submitting written work at ETH Zurich' (http://www.umwelting.ethz.ch/download/index) is to be placed directly after the title page of the Master project, on the right-hand side.

Final Presentation

The final presentation of your Master project is the highlight of your research. You have 25 minutes to hold your lecture. The target group is an expert audience. They are the focus of your presentation.

5.4 Evaluation

The Master project thesis will be evaluated and graded according to the criteria of evaluation in the annex.
Report

The report will be corrected by your advisor. After the correction, usually the advisor will set up a written feedback to the student, together with the corrected copy.

Final Presentation

Directly after the presentation, the final presentation will be evaluated and graded by the advisor, assistants and head of Master project. The assistants will set up a written feedback.

5.5 Office Hours

You may arrange meetings with Professor Morgenroth (eberhard.morgenroth@ifu.baug.ethz.ch; HIL G31.3) for the Master project by e-mail. The consultation hours of the assistants (eppler@ifu.baug.ethz.ch; HIL G 31.2) are:

- Tuesday: 15:00 – 17:00
- Wednesday: 14:00 – 16:00
- Thursday: 10:00 – 12:00

You can also write an e-mail to arrange an appointment or ask questions.

5.6 Tools, Documentation

The most important documents and project records are found on our homepage: http://www.ifu.ethz.ch/SWW/education/projects

At the end of this documentation, there is a list of literature with interesting and useful publications.

5.7 Working Place

There are PCs in room HIL C 42.2 for the Master project work. The regulations in the following subchapters must be read and all users are requested to respect the rules.

5.7.1 General rules

Room C 42.2 is at your disposal as a working place. In order to ensure a smooth course in this computer room, we request our user to keep to the following rules:

- The last person in the room must switch off all computers and lights, and close the door. The room must never remain open if nobody is in there.

- The participants will receive an electronic access to the computer room for the length of the Master project. The access to the room is with their activated student card. The card reader will recognize the activated card automatically.

- To allow fast working, it is necessary to work on the local drive D:\. Do not forget to back up your data on the server. **ATTENTION: DATA SECURITY IS NOT GUARANTEED ON THE LOCAL DRIVE!**
The study-oriented work has the highest priority for using the computer. All other activities (i.e. surf, game, etc.) are of a lower priority.

5.7.2 Login
The account is name SWW-MP04. The initial password is given below. After starting the computer you must unlock the screen by pressing the buttons Ctrl+Alt+Delete and filling in the login screen with the following credentials:

<table>
<thead>
<tr>
<th>Username</th>
<th>SWW-MP04</th>
</tr>
</thead>
<tbody>
<tr>
<td>Password</td>
<td>abcd1234.BC</td>
</tr>
<tr>
<td>Domain</td>
<td>IFU</td>
</tr>
</tbody>
</table>

Please alter the password after the initial login.
The designated computer in the computer room HIL C42.2 has the number 13. See the floorplan below for an orientation.

5.7.3 Data protection
While working with WinASIM, Word, Excel, etc. you must always save your data locally on the hard disk. At the end you have to back up your data.
If further programs are required which are not installed, inquire at the assistance. The hard disk is write-protected, e.g. you cannot download programs from the network.
6 References

This list does not claim to be complete. Certain publications can be found in the general documentation of the Master project, others can be lent from the assistants. Additionally, at the assistance more specialist books can be lent out.

Information to laws and regulations can be downloaded from the internet (www.admin.ch).

Literature:


Laws and Regulations:

- Bundesgesetz über den Umweltschutz (Umweltschutzgesetz) vom 7. Oktober 1983, SR 814.01
- Gewässerschutzverordnung (GSchV) vom 28. Oktober 1998, SR 814.201

Useful Links:

Laws and regulations: http://www.admin.ch/

Homepage of the Association of Swiss Experts in Wastewater and Water Pollution Control: http://www.vsa.ch/

Chair of Urban Water Management: http://www.ihw.ethz.ch/SWW/index


English-German or French-German online dictionaries: http://www.leo.org/ or www.linguee.de

Web of Science: http://isiknowledge.com

ETH Library: www.library.ethz.ch

Do not hesitate to search for further information at the ETH library (www.nebis.ch). Also the books at the assistants’ office (HIL G 31.1) are at your disposal (use loan-out list).

Another useful source for scientific publications is the Web of Science (http://isiknowledge.com). Web of Science is an internet database where many abstract of published papers are deposited. There, you can search for papers by using specific criteria such as keywords, author, citations, etc. Note that free access to the Web of Science requires that you are part of the ETH network or that you link to the ETH network via VPN. The ETH-library (www.ethbib.ethz.ch) has online-subscriptions for many scientific journals so that you can download necessary articles in full length.
## 7 Annex

### 7.1 Criteria for the Evaluation of the Master Project

<table>
<thead>
<tr>
<th>REPORT AND ANNEX</th>
<th>60 %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LAYOUT</strong></td>
<td>20 %</td>
</tr>
<tr>
<td><strong>Form</strong></td>
<td></td>
</tr>
<tr>
<td>The actual report may not exceed 25 pages (not counting the index and appendix).</td>
<td></td>
</tr>
<tr>
<td>Is the layout clear and appealing?</td>
<td></td>
</tr>
<tr>
<td>Is the text comprehensible and easy to read?</td>
<td></td>
</tr>
<tr>
<td>Are the quotations and references correct and unitary?</td>
<td></td>
</tr>
<tr>
<td><strong>Text structure</strong></td>
<td></td>
</tr>
<tr>
<td>Is the report without the annex easy to understand?</td>
<td></td>
</tr>
<tr>
<td>Are the chapters organized in a logical sequence? Is each chapter in itself complete?</td>
<td></td>
</tr>
<tr>
<td>Is the abstract of the report concise, clear, and conveying the major findings of the report?</td>
<td></td>
</tr>
<tr>
<td>Are the figures and charts informative? Are they well incorporated into the text?</td>
<td></td>
</tr>
<tr>
<td>Are report and annex sufficiently linked?</td>
<td></td>
</tr>
<tr>
<td>Does the annex contain all data for an in-depth study of the work?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONTENT</th>
<th>80 %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proposed tasks addressed in report</strong></td>
<td></td>
</tr>
<tr>
<td>Were the focus areas of the task recognized? Was the aim consequently formulated?</td>
<td></td>
</tr>
<tr>
<td>Was the concept of procedure direct and did it fit into the time schedule of the Master project?</td>
<td></td>
</tr>
<tr>
<td>Were the main theoretical basics properly developed and presented?</td>
<td></td>
</tr>
<tr>
<td><strong>Critical discussion of data and results</strong></td>
<td></td>
</tr>
<tr>
<td>Does the description of the practical work allow an evaluation and repetition of the data assessment?</td>
<td></td>
</tr>
<tr>
<td>Are the assumptions adequate and correct?</td>
<td></td>
</tr>
<tr>
<td>Were the basic principles from the obtained calculations/results completely listed?</td>
<td></td>
</tr>
<tr>
<td>Did a critical evaluation of the data quality occur?</td>
<td></td>
</tr>
<tr>
<td><strong>Calculations and results</strong></td>
<td></td>
</tr>
<tr>
<td>Was the data analyzed with the appropriate process and with the necessary care?</td>
<td></td>
</tr>
<tr>
<td>Are the assertions and calculations correct?</td>
<td></td>
</tr>
<tr>
<td>Were all essential results shown?</td>
<td></td>
</tr>
<tr>
<td>Were all models referring to an application correctly compiled?</td>
<td></td>
</tr>
<tr>
<td>Were all models properly applied, in relation to the calibrated and validated problem?</td>
<td></td>
</tr>
</tbody>
</table>
Discussions and conclusions
In the discussion, were the results critically evaluated and compared with the corresponding literature? Were the individual tasks connected to the overall project (importance of the results within the over-all summary)? Is the discussion relevant for the purpose? Are the conclusions clear and justified? Are conclusions linked to the purpose defined in the introduction? Have the unresolved questions been identified as recommendations for further study? Were useful suggestions made for a further procedure?

Summary
Does the report contain a concise, clear und complete summary (max. one A4-page with the set task, aim and purpose of the report, important results and conclusions and references).

PRESENTATION 20%

GENERAL IMPRESSION 20%

Validity: Are the statements in the presentation clear? Are these well prepared by way of explaining the procedure or by displaying the results? Are the statements well communicated to the audience? Are the contents convincing?

Conclusions: Are the conclusions of the Master project comprehensible and correct? Are constructive suggestions made for a future procedure?

Answer to questions: Are the questions clearly and explicitly answered? Are the statements correct?

TECHNICAL CONTENT 20%

Information content: Are necessary assumptions presented? Have the models been correctly explained? Are the results interpreted and also drawn into the conclusion?

Fairness to audience: Is the content of the presentation suited to the audience?

Comprehensibility: Are the contents presented in a simple and logical way? Is a central theme noticeable and are parts of the statements relevant to the presentation?

Quality: Are the models applied suitable? Are the calculations correct? Has the data used been queried? Are there any inquiries as to uncertainties?

PRESENTATION TECHNIQUE 20%

Structure: Is the structure understandable and logic? Is the structure conform to the content? Did it help to present the content as plain and as complete as possible?

Introduction / Conclusion: Is there a clear introduction in the presentation so that everybody in the room knows: it has started? Is the conclusion of the presentation well-stated?

Introduction: Is the audience properly introduced into the task? Is the context of the work obvious? Is the aim of the thesis stated? ⇒ gain their attention!

Main part: Are the main statements explicit? Are they easy to understand? Are the statements well prepared by the methods and models explained? ⇒ Convey main statements clearly!
**Conclusion**: Is the content of the presentation well summarized? Are the main statements repeated (take home message)? Is a possible prospect useful? → emphasize main statements!

**Time frame**: Was the given time frame of 25 minutes kept?

---

**USE OF MEDIA 20%**

**General**: Was appropriate media applied for the information transfer? Is the presentation livelier because of the use of media? → Media can support the lecture, but does not replace it.

**Handling of media**: Was the media properly handled? Is the projection sharp, the picture straight? Is the flip chart visible for all in the audience? Can the text written on the wall chart be read from the very back of the room? Is the use of pointer efficient?

**Transparencies**: Is the layout simple so that the listener is not distracted? Does it support what is being said? → Limit yourself to „need to have“. Is the writing readable? Are the shown graphics quick to understand (axis label, legend, use of color, differences of symbols)? Are transparencies introduced („These are the results of a stream experiment …“, what do you see? Guide the listener through the transparency!)?

**Wall chart**: Is the writing big enough and readable? Make sure not to stand in front of the wall chart, otherwise important statements might not be seen. Pay attention to the 3 T (Touch, Turn, Talk).

**Flip chart**: Is the writing big enough and readable? Keep in mind the 3 T (Touch, Turn, Talk).

**Handouts**: It can be useful to make handouts of important transparencies and distribute these. Are they included in the presentation? Attention: Handouts can distract the listener from the lecture. → Hand out in due time.

---

**EXPRESSION 20%**

**Language**: Is the language fluent? Are the sentences simple and short? Is there a pause within the sentence when important statements are made so that the audience can notice them? Are terms clearly defined and placed unitary and correct?

**Presence/Contact with the audience**: Is the audience spoken to? Is the presence convincing and professional? Was this „platform“ used (movement makes the lecture lively, animates the listener)?

**Mimic/Gesture**: Where are the hands, are these under control (do not cross the arms → appears to be defensive, do not put your hands in the trouser pockets → seems casual, but is in fact unprofessional)? No gestures of embarrassment (i.e. scratch the back of your head, place fingers in front of your mouth, etc.)!

This catalogue of criteria is not complete. The above-listed questions just serve as indications for the evaluation of the thesis.

---

**PRACTICAL WORK 20 %**

---

**PROJECT MANAGEMENT 40 %**

**Time schedule**: Was a time schedule set up? Are important work stages documented? Was enough time planned for the documentation of the work?

**Problem identification**: Is the problem critically queried? Is the task within a relevant context?

**Goal**: Is the goal in spite of the problem identification correct? Does the goal fit in with the context of the Master project?
Organization of work: Is the work place properly furnished? Does the candidate work independently? Does the candidate cooperate with the supervisor and other persons? Is there a control of the work progress?

SIMULATION WORK 60%

Preparation: Are experiments prepared? Is the aim of the experiment clear? Are the experiments in the draft aim-orientated? Is the required material all put out?

Experiments: Are the experiments performed as according to the plan? Are the experiments done in a proper and exact way? Are the samples clearly labeled?

Documentation: Is a lab journal kept? Is the record of the experiments correct, precise, complete and in detail?