Laboratory Record

Each student has to take own laboratory records. These laboratory records have to be kept in bound form (bound book, not a folder) in A4-format. Quad paper is recommended, since this allows for an efficient and clear form of taking the laboratory record. An experiment can only be performed, if the laboratory record is carefully prepared.

The laboratory record has to be regarded as a documentary proof of the experimental work done. Sometimes laboratory records can be essential in legal matters such as patent or copyright controversies or in scientific matters such as claims of originality or first observations. Therefore all records should be made with document proof writing materials (ink, ballpen, etc.) and should be reasonably complete and self-contained. In case of sketches and graphs, the latter on millimeter paper or specialized graph paper, pencils might be used. Graphs made with scientific software have to be printed and pasted into the laboratory book.

In the following a recommendation is given for the structure of a clearly arranged and exact laboratory record. The head should contain: name, date, study course, name of the experiment, tasks, list of instruments. This and the first section “Basics” have to be prepared at home. A careful and comprehensive preparation of the experiment is a prerequisite for the admission to the experimental session.

1 Basics (Preparation before the start of the experiment)

In this section the basic physical laws have to be reviewed that are necessary for the solution of the experimental tasks. Important equations have to be written down; the concepts behind these equations and their deduction have to be briefly sketched. Equations needed for the calculation or estimation of the measurement uncertainty, especially equations concerning error propagation, have to be derived and written down (Measurement uncertainty). Measurement methods and techniques, instruments, electrical circuits etc. should be briefly sketched. The experiment should be planned to allow for an efficient measurement sequence and procedure. Tables necessary for the recording of measurement values and for the data evaluation should be prepared.

2 Measurement values

Directly measured values are entered into appropriate tables that eventually also contain additional columns for conversion or intermediary results. Uncertainties in reading or setting measurement values, manufacturer’s information on instrument accuracy, other instrument-specific data relevant for the estimate of measurement uncertainty as well as experimental and environmental (e.g. air pressure) conditions have to be noted. It is often useful to make simple numerical estimates on the correctness of the results already during or briefly after the measurement. This helps in spotting inappropriate values or parameters ranges before the extensive data analysis starts.

3 Analysis

The calculations as well as the most important intermediary results have to be written down. Graphical representations and analyses have to be done using appropriate scales. Graphs made with scientific software have to be printed and pasted into the laboratory book.

4 Measurement uncertainty

Systematic and statistical measurement uncertainties should be noted. In case of single measurements usually a maximum error estimate for the determination of the measurement uncertainty should be made. In case of a series of measurements that contains values with statistical deviations following a Gaussian distribution, the confidence interval has to be calculated assuming a confidence level of 95%. For more information on the estimate of the measurement uncertainty consult the supervisor, this brief guide (...) as well as the literature, e.g. the book “Physikalisches Praktikum”, Hrsg. D. Geschke, B. G. Teubner Stuttgart-Leipzig.

5 Summary (Results and Discussion)

The laboratory record is concluded with a summary of the results as requested by the experimental tasks. Statement of the results always includes measurement uncertainties. Numerical values should be rounded to the number of significant digits as indicated by the measurement uncertainties; the latter should be specified with at most two leading digits. The most important sources of error should be briefly specified. The discussion should focus on:

- a comparison with known (e.g. tabulated) values
- the agreement with theoretical relations
- a comparison with alternative measurement techniques
- the different influence of systematic and statistical measurement uncertainties
- the uncertainty of the measurement value as well as a critical examination of further sources of error.

Some hints on the preparation of graphical representations:

Graphical representations are of particular importance for the presentation of measurement values and the determination of physical values. In the preparation of graphs, independent of the use of millimeter paper or scientific software, the following rules should be observed:

- Each graph should have a caption that clarifies the functional relationship represented.
- The scale of the coordinate axes should be chosen in such a way that the angle between the graph (at least in the range where it is evaluated) and a coordinate axis is about 45°.
- The coordinate axes have to be labelled with the physical variables and the corresponding units. The units appear behind the variable names either separated by a slash (/) or set in round brackets (...).
- The measurement values are represented by unique symbols (crosses, open circles, etc.) and should be clearly discernible besides the theoretical curve (e.g. best-fit line). Measurement uncertainties can be added as error bars.