GYPT
German Young Physicists' Tournament 2021

Written Report

Guidelines for Participants

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1 General Information

This document is written to provide you, the participants of the German Young Physicists' Tournament, with the relevant guidelines for the written report. It outlines the basics concepts of scientific writing in combination with some best practice advices to scientific research. Additionally, the desired structure of a GYPT report as well as the scientific and formal evaluation criteria are briefly summarized on the following pages.

All reports will be evaluated in correspondence to a regular GYPT presentation on a scale from 1 to 10 points. We are, however, aware of the fact, that this is the first scientific report for most of you. Therefore, this guide is not meant to be followed in every single detail in order to achieve the maximum score of 10 points. To outline the differences in grading among the reports submitted, each section is followed by a green box which briefly summarizes the most important aspects of the respective chapter.

sufficient

fair

good

The detailed scoring guidelines are stated in table 3.1 on page 10.

However, this document is not meant to set up strict regulations, but to provide you with some guidance when you summarize your research results.

We therefore highly encourage you to submit your results either way, no matter whether they follow the suggested criteria or not.

Please feel free to contact me with any further questions or remarks regarding your written report or this document itself (florian.ostermaier@nlogn.org).

1.1 Formal Requirements

First of all, your submission should satisfy the formal requirements. Those are:

- language: English
- page limit: 15 pages (excluding title page, table of contents and bibliography)
- minimal font size: 10pt
- PDF format

Please note that even though the report is limited to 15 pages in total, this is not the benchmark to be awarded with 10 points. A target length of approximately 4–6 pages is satisfactory for most of the cases.

1.2 General Outline

As the GYPT report is intended to relate to the basic principles of scientific research papers, we recommend you to follow a predefined outline. Your final report should therefore consist of the following individual parts, which should be clearly distinguishable:

1. Title Page (p. 4)
2. Introduction (p. 4)
3. Main Part: Own Research (p. 5)
4. Discussion and Outlook (p. 8)
5. Bibliography (p. 8)

The special requirements to all parts are explained in greater detail in the following document. Besides all other requirements, the report should strongly focus on the main part and therefore on the own research conducted. As a fair proxy, the individual maximum scores specified in the evaluation criteria (p. 10), might roughly correspond to the share of the individual sections of the whole document. Accordingly, the main part describing your own research (5/10 points) should account for more or less half of your report.

2 Structure of the Report

2.1 Title Page

Of course, every document comes with a title page which basically names the title of the work together with all participating authors. For the GYPT written report, we ask you to include the following attributes to your title page:

- number and title of the IYPT problem, year
- author (name, e-mail)
- GYPT team name
- other team members
- date of submission
- supervisors & institutions involved , if any

Optionally, the title page can be followed by a short table of contents listing the following sections.

2.2 Introduction

The introduction should provide a clear quotation of the IYPT problem posed. Further, it should briefly explain the scientific background of the problem statement. It is normally terminated by a short outline of your approach to the problem together with a formulation of your testable hypothesis. In general, there is no *correct* way of writing a good introduction. Yours might, however, address the following questions (if applicable to your problem):

Interpretation of the task It might be helpful to actually write down your own interpretation of the task in 1 or 2 sentences. Some common interpretations of common phrases are listed in a separate GYPT tutorial [1, p. 21].

Preliminary experiment For some of the problems, a preliminary experiment can be conducted without any further equipment. For those problems, it is very common to include a first picture/observation into the introduction.

Background research If you do not fully understand your problem (yet), go ahead and google it. Briefly describe some of the material you have found and how they could be relevant to your question. If possible, try to stick with one consistent reference system[1].

[1] http://www.scientificstyleandformat.org/Tools/SSF-Citation-Quick-Guide.html

Qualitative hypothesis to the phenomenon Based on your preliminary experiment and some background research, what could cause the investigated phenomenon to happen? What seem to be the key parameters influencing it? Try to address at least one key parameter and predict a possible trend (*hypothesis*) if one would systematically vary it.

Your approach Give a brief summary of the approach used to solve the problem/investigate the previously posed hypothesis.

sufficient	correct quotation of IYPT task, preliminary experiment
fair	references to related phenomena in scientific literature, first qualitative hypothesis
good	task is placed in proper relationship to available scientific resources, detailed and correct description of the hypothesis and its dependency on multiple relevant parameters

2.3 Main Part: Own Research

The main part of the document should consist of a detailed description of one (or more) experiment(s). The outcome of this should clearly show the relationship of two parameters which have been varied independently from each other. Your text should contain a short justification on why this specific parameter has been chosen to be investigated and how experimental problems have been overcome.

Theoretical model In most of the cases, a first trend is obvious from preliminary experiments. But how can this trend be quantified? If you are not sure on whether the equations you have found really relate to your problem, feel free to ask the mentor of your problem[2] for advice. On this basis, try to develop a **final equation** containing both, the independent variable (the variable you vary) as well as the presumably dependent variable (the variable you measure). This equation should be derived from commonly known base equations you know from school. The experts among you might consider the following guidelines for all written equations:

- All non-obvious equations taken from literature should be properly cited.
- All used variables should be annotated together with the physical quantity they represent. Example:

  …the Hagen–Poiseuille equation [2]

  $$\Delta P = 128 \frac{\mu L Q}{\pi d^4} \tag{2.1}$$

  where

  ΔP : *pressure reduction*
  μ : *dynamic viscosity*
  L : *length of the pipe*
  Q : *volumetric flow rate*
  d : *pipe diameter*

[2] `https://gypt.org/materialien/projektmentoren.html`

- Specify all values taken from literature. Experts among experts even include the source of the values together with the estimated uncertainty. Example:

  $$\textit{…dynamic viscosity of water[3]: } \mu_\mathrm{w}\left(20\,^\circ\mathrm{C}\right) = (1.0 \pm 0.1) \times 10^{-6}\ \mathrm{mPa \cdot s}$$

- Good reports have a consistent variable naming throughout the whole document.

Your final equation should further be named together with its boundary conditions. If for example you use an equation that is only valid for incompressible fluids, on your way down to your final equation, the latter will also require this condition to hold. In the end, analyze your model in terms of its proportionalities and state a clear hypothesis (*"We would therefore expect a quadratic relationship between the distance traveled and the measured time*).

Selection and Measurement of a Key Parameter Once you have set up your theoretical model, it should be possible to identify a parameter which is comparably easy to be investigated.
If we were, for instance, to investigate the relationship between the velocity v and the time t of an object during free fall, we could derive

$$E_\mathrm{pot} = E_\mathrm{kin} \tag{2.2}$$

$$mgh = \frac{1}{2}mv^2 \tag{2.3}$$

$$v = \sqrt{2gh} \tag{2.4}$$

using the object's mass m and the gravitational constant g.
These equations are conventionally solved for the measured dependent variable v, so that all independent variables are aligned on the right hand side of the equation. In this example, we would obviously pick h instead of g to prove this relationship. Generally, you should **always start with the parameters that are the easiest to vary**.

Experimental Verification When testing this parameter against your hypothesis, the following things should be included in the written report:

- A detailed description of the experimental setup with all important items clearly labeled. It is good practice to draw sketches of the relevant parameters into the photograph. In addition, this figure (as all others too) should include a short caption describing it's contents. A specific example is shown in figure 2.1.
- Write the experimental procedure like a step-by-step recipe for your experiment. A good procedure is so detailed and complete that it lets someone else duplicate your experiment exactly.
- Is your experiment reproducible? Can it be repeated multiple times with the same result/outcome?

Data Analysis & Evaluation The description of the experiment is then often followed by a presentation of the measured data and its analysis. Hereby, you test your theoretical model against the measurement data obtained in the previous step. In this example, we measure the gravitational constant g by video tracking of a falling object. The theoretical model can be obtained by integrating (2.4) with respect to time t. It yields for the initial height h_0

$$h(t) = h_0 - \frac{g}{2}t^2 \tag{2.5}$$

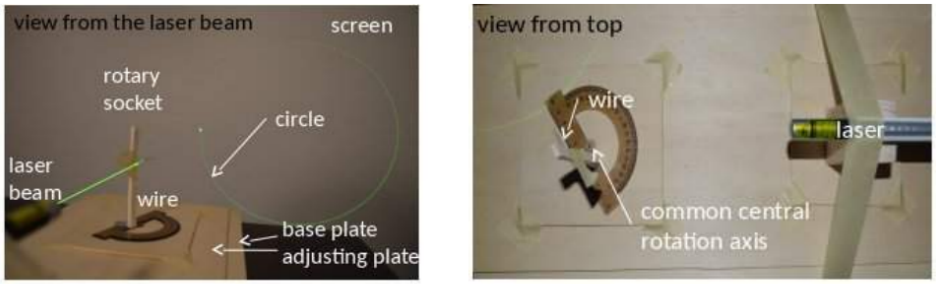

Figure 3: This is how the setup looks like. The incidence angle of the laser beam as well as the distance from the incidence point on the wire and the screen can be easily adjusted. (Setup and picture by Simon Blumreisinger)

Figure 2.1: Exemplary description of the experimental setup used. All relevant components should be clearly labeled. All figures should be captioned with a short description.

It is displayed together with a sample measurement in figure 2.2. Please note that it is good scientific practice to include *error bars* for the measured points indicating the accuracy of your measurement points. The theoretical model is then fitted onto the measurement data in search for the unknown parameter g. The sample measurement then yields a result of g =

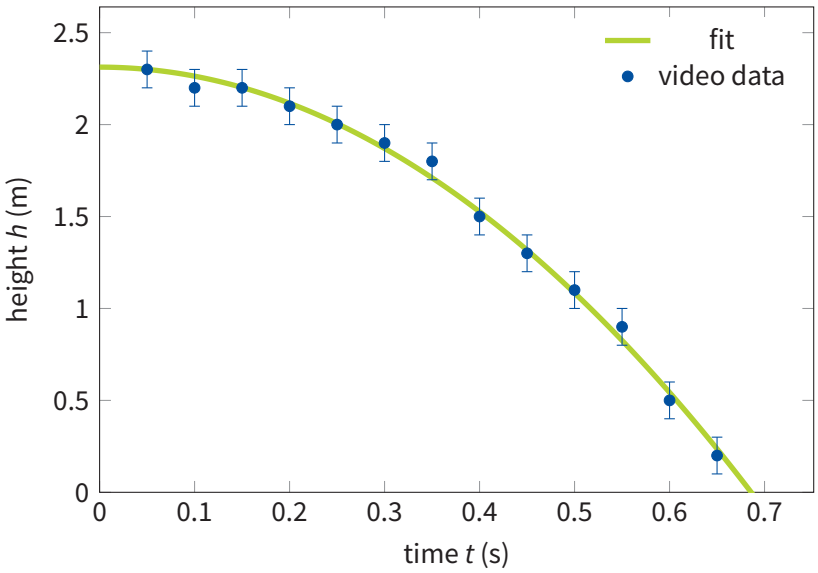

Figure 2.2: Measurement results: The measurement data obtained from the video (blue) fits to the theoretical prediction (green) for $g = (9.82 \pm 0.03)\ \mathrm{m/s^2}$.

$(9.82 \pm 0.03)\ \mathrm{m/s^2}$, which is in good agreement with the well-known literature value $g_{\mathrm{lit}} = 9.81\ \mathrm{m/s^2}$. Please be sure to

- label all axes with the physical quantity and the unit
- discuss your measurement error in any way
- comment on the precision of the parameters obtained from the measurement

sufficient	systematic variation of one parameter, first ideas on a theoretical model
fair	appropriate experimental setup, systematical variation of one key parameter, reasonable theoretical prediction and comparison
good	correct and flawless investigation of several relevant parameters, elaborate theoretical model, that is able to predict major aspects of the phenomenon

2.4 Discussion and Outlook

The last part of your report should bring your experiment(s) in line with the general task addressed in the introduction. It is to summarize what has been done and what is still to do in order to answer the previously addressed questions sufficiently. A good Discussion mentions findings on different aspects of your hypothesis and draws clear conclusions from the experiments. Further, you should pay special attention to the validity of conclusions you draw based on the experimental data. There might be several possible physical effects reflected in your data which all contribute to the measured outcome. It is therefore completely fine to give an assumption in the sense of *"it might be possible, that…"* instead of stating a clear opinion that cannot be derived from the experimental data.

Lastly, your discussion should include a brief summary on which parts of the problem have been tackled so far and what is still to do. Hence, it is good common practice to include a brief outlook on the additional research to be conducted based on what you learned so far.

sufficient	Decent summary of the previous report
fair	Appropriate and complete summary, discussion of the measured data
good	Discussion on the range of validity of all parameters investigated, own opinion clearly stated and backed up by experimental data, discussion on the work left to do

2.5 Bibliography

All external sources should be listed in a *bibliography* at the end of your document. It does thereby not matter whether you use mainly online sources or books. But please keep in mind, that the reader would want to check your sources for further details on the referenced statements. Your sources should therefore be complete and unique. The format of your sources, however, does not matter as long as it is consistent. So if you decide to abbreviate the authors first name by only one letter, this should be done for all references. Possible examples for cited works would therefore look as follows (with explicit examples printed in blue):

Books Author, *Title*, Publisher, Publication Date. Example:

D. Halliday, R. Resnick, and J. Walker. *Fundamentals of Physics*. 10th ed. Wiley, 2013. ISBN: 978-1118230718.

Journals Author, “Title”, In: *Journal* (Issue/Year), Pages. Example:

A. Einstein and N. Rosen. “The Particle Problem in the General Theory of Relativity”. In: *Phys. Rev.* 48 (1 1935), pp. 73–77. DOI: 10.1103/PhysRev.48.73

Web Pages Author, *Title*, Publication Date, URL, Date visited. Example:

F. Wechsler. *GYPT Tutorial 02: Ein Problem Angehen*. German. 2016. URL: https://gypt.org/files/02_ProjectStart.pdf (visited on 09/30/2010)

3 Evaluation Criteria

All reports are evaluated in correspondence to the real GYPT scale on a range from 1-10 points. The final score is calculated by adding all points from the different sections of your report as specified in table 3.1. Besides the sections introduced above, there will be a maximum of 2 points added for formal criteria such as respecting the page limit and proper citations. However, special attention will be payed to the main part describing your own research in which you can achieve 5/10 points.

Table 3.1: List of all evaluation criteria. The listed items contribute equally to the score reached in the respective section of the report.

Section	Points
Introduction	**1**
quotation of IYPT task qualitative hypothesis brief review of background research outlines the key questions addressed in the report	
Main Part: Own Research	**5**
appropriate and relevant theoretical model physical correctness of model theoretical prediction of at least one experimental trend description of experimental setup experimental effort suitable experiments, quality of experimental techniques reasonable and appropriate error analysis comparison of theory and experiment overall scientific approach	
Discussion and Outlook	**2**
validity of conclusions clear separation of own opinion reference to the task reasonable explanation of open questions	

Table 3.1: *continued from the previous page*

Section	Points
Formal Criteria	**2**
title page, consecutive numbering of all pages clear and appropriate language figures and symbols clear and understandable proper citation of references page limit not exceeded clear overall structure	

Bibliography

[1] F. Wechsler. *GYPT Tutorial 02: Ein Problem Angehen*. German. 2016. URL: https://gypt.org/files/02_ProjectStart.pdf (visited on 09/30/2010).

[2] S. P. Sutera and R. Skalak. "The History of Poiseuille's Law". In: *Annual Review of Fluid Mechanics* 25.1 (1993), pp. 1–20. DOI: 10.1146/annurev.fl.25.010193.000245.

[3] W. Haynes. *CRC Handbook of Chemistry and Physics, 93rd Edition*. CRC Handbook of Chemistry and Physics. Taylor & Francis, 2012. ISBN: 9781439880494.