Ferdighetsstreng XFys

Erik Wahlström

Instituttleder

Institutt for fysikk

Background

Focus: The physics related study programmes – roughly 180-220 students.

Problems with the continuity between courses the study programs initiated a process regarding ferdighetstrenger.

The revision started in 2018 based on the Study programe valuation 2015 and a mission and vision document from 2017.

The aim is to take a holistic approach concerning skills and experiences needed in the projected workspaces for the students.

Setting goals

Goals for XFys

- Teach how to **use physics and physical concepts to solve problems** of any kind

- **Rework lab exercises** and remove recipe style instructions. Replace with some tasks that promote independent experimentation

- **Change focus towards the process** instead of just fixating on the final results. (learn to solve problems not reproduce known solutions)

- **Motivate and communicate the changes** and explain why this is beneficial to the students

Goals (motivation for students)

- Show our students **how physics and physics skills can be applied** to address a wide range of tasks and problems.

- **Widen their skillset**: They will become well versed problem solvers and are able to bridge the gap between practical/engineering tasks and theoretical solutions.

- These skills are **attractive both for our research groups and industry** and will open up new possibilities and career choices for our students.

Skills

- General skills
- Methodological
- Documentation and communication
- Models and uncertainty
- Analysing data
- Ethics and safety

Based on Feisel, L. D., & Rosa, A. J. (2005). The role of the laboratory in undergraduate engineering education. *Journal of engineering Education*, *94*(1), 121-130.

Fulfilling the goals - status 2022

Not as far as we would have liked

- The COVID-situation was a large set-back of the development and hampered the development seriously – weak communication became too weak.
- First year becoming more complete
- Dependencies between courses are hard to track
  - Organised and meaningful training of skillsets relies on good coordination between courses.
- Moved from one responsible for coordinating several different course responsible to one responsible for the execution of labs and exercises.

Teknostart - Goals

- Work in groups
- Plan work and document plans
- Present project orally

Project:

- Design and build a “boat” with magnetohydrodynamic propulsion

Target:

- The “boat” should be as fast as possible

FY1001 Mechanical Physics (semester 1) - Goals

- Write laboratory journal
- Error analysis
- Use video-analysis of motion
- Combine experiments and numerical calculations
- Write report using template

Experimental work/Project:

- Collisions, video-analysis of 2D collisions
- Cavendish experiment, determining G and error analysis
- Experimental/numerical project, cylinders/spheres on quarter circle track (semester project)

FY1003 Electricity and Magnetism (semester 2) – Goals (preliminary)

- Write Report
- Error analysis – sensors, systematic errors
- Use data acquisition system
- Plan and design measurements

Experimental work/Project:

- Measuring magnetic fields
- Lorentz force, e/m determination, error analysis
- Experimental project, determine the magnetic inclination and declination using the sensor in your smartphone (semester project)

Teaching

Laboratory seminars

- 2 – 3 Lab-seminars per semester
- Subjects related to lab and learning objectives
  - Semester 1
    - Documentation and video analysis
    - Error analysis and reports
  - Semester 2
    - Follow-up last semesters report, more on reports, planning experiments
    - Error analysis, metrology, reports
  - Semester 3 & 4
    - Under development..

Projects

- Aim: to let students apply their physics knowledge on an “open” question.
- 1 project per semester
- Project related to courses and learning objectives
  - Semester 1
    - Combined numerical and experimental project
    - Simulation of cylinder on quarter circle and comparison with experiment
  - Semester 2
    - Determination of magnetic inclination and declination with use of Smartphone (PhyPhox or Physics Toolbox). Under development.
  - Semester 3 & 4
    - Under development..

Important lessons learned

- COVID….

- When changing large courses relying on collaboration is not enough -> Proper delegation and role clarification very important.

- Modified for examination a large challenge – how to make lab assessment count – have induced a discussion on a second revision

Skills

Our physics education at NTNU wants to provide students with the capability to:

- approach complex problems independently and with confidence.
- analyze problems and risks, find the key elements to a problem and use critical and creative thinking to solve it.
- understand the role of uncertainty, errors and ambiguity when analyzing a problem and use this to identify solutions fast and efficiently.
- be “frustration resistant” since they can deal with failures, uncertain situations and uncertain outcomes -> Thus they are the right persons to put onto open-ended problems.
- Be good communicators, such that they can receive, execute and communicate results, conclusions and methods to any audience.
- be effective and efficient team players in multi-disciplinal environments.
- distinguish between different roles and goals they can occupy in groups and team-based efforts and know how to master them.
- provide students with a transferable general skillset that can be used in any task.

Methodological skills:

The experimental training should enable the students to:

- plan and design experiments in accordance with the specified goals
- chose the suitable instrumentation and software for the task at hand
- test, calibrate and debug experimental setups
- use appropriate data collection and data handling routines (ensuring that data and metadata are secure, accessible and archived)
- ensure that the collected data is valid by performing suitable checks of e.g. the reproducibility of the data and safeguards against experimental artifacts

Documentation and communication:

The experimental training should enable the students to:

- completely document the experimental process (lab-journal) including goals, measurement methods, accuracy and possible problems
- create written reports that present the results effectively, precisely and comprehensibly.
- be able to comprehensibly present data orally.
- to communicate motivation, data, data analysis and results efficiently, effectively and with the appropriate methods suited for the chosen target audience.

Models and uncertainty:

The experimental training should enable the students to:

- choose appropriate models to describe the experiment and the data
- understand strengths and weaknesses of models
- understand that models are based on assumptions and that they are a simplified description of reality
- understand the multiplicity of models (different models can be used to describe the same system)
- understand the role of model experiments and model independent experiments in physics
- understand the role and consequences of uncertainty and limitations in physical experiments

Analyzing data:

The experimental training should enable the students to:

- understand the role of metrology in data collection (e.g. the use of measurement systems, measurement standards etc.)
- critically analyze and interpret the data
- extract and condense the core information from large datasets
- perform suitable error analysis on their data sets
- reach defendable conclusions based on the data (e.g. understand the difference between correlation and causality)

Ethics and safety:

The experimental training enables the students to:

- understand and follow scientific ethics standards in experimenting and reporting (add reference to the current criteria)
- make appropriate risk assessments for their experiments by evaluate health, safety and environmental consequences
- implement appropriate safety measures to minimize risks