Friedrich-Ebert-Gymnasium, Bonn

Gymnasium der Stadt Bonn mit internationalem Profil

Bilingual deutsch-französischer Bildungsgang und bilingual deutsch-englische Bildungswege

School code: 000973

Physics Analysis and Approaches
SL & HL
including the German Physics Curriculum

The Physics curriculum of the IB Diploma Program and the national curriculum are combined and taught simultaneously at our school. Though candidates benefit from common requirements and synergetic effects, several topics are only covered by one curriculum. Candidates take three to five 45-minute-classes per week depending on the level they choose in the German course of education and two 45-minute-classes to prepare them for the additional requirements of the IB Diploma Program.

Teachers who completed this outline:

Matthias Seuffert / Boris Dirsch
Date of last IB training: 10/2023

Resources:

Oxford Resources 2023 Edition Physics Course Companion
Old exam questions
Geogebra
Excel
Many experiments available in our laboratory.

Course outline

The national curriculum is expanded on the additional topics as indicated in the second column of the table. While the SL students work on exercises on the topics, additional thematic content is dealt with the HL students. Some topics of the IB physics diploma is taught in the **German physics class (GPC)** before the start of the IB program, some material is not taught in GPC, and other parts are taught in addition in GPC.

<table>
<tr><th></th><th>National Syllabus Content
Standard Level and Advanced Level</th><th>Additional Material
Standard Level and Higher Level</th></tr>
<tr><td></td><td>Preliminaries

Fundamental and derived SI units, scientific notification and metric multipliers, vectors and scalars,</td><td>Uncertainties and errors. Writing a lab report, creating graphs with error bars using a computer</td></tr>
<tr><td></td><td colspan="2">Practicals:
g-determination with different methods (possible because the students know already know the required physics from lessons in the previous year)</td></tr>
<tr><td></td><td>Kinematics

velocity, uniform and non-uniform acceleration, motion graphs, projectile motion, equations of motions, movement under the influence of fluid resistance, angular velocity</td><td>Difference between distance and displacement</td></tr>
<tr><td></td><td colspan="2">Practicals:
Free falling balls</td></tr>
<tr><td></td><td>Forces and momentum

Newton's laws, free body diagrams solid,
Friction, buoyancy

conservation of momentum, collisions

Circular motion, centripetal force</td><td>Tension,
$F = \frac{dp}{dt}$, in particular in situations where m is not constant</td></tr>
<tr><td></td><td colspan="2">Practicals:
Determination of the coefficient of friction using different methods.
Analysis of falling cones
Hooke’s law</td></tr>
<tr><td></td><td>Work, energy and power

Kinetic, potential, elastic energy. Principle of energy conservation,

Power</td><td>P=F v
Efficiency
Energy density of fuel sources</td></tr>
<tr><td></td><td colspan="2">TOK: Examining Assumptions and Models: Prompt students to critically evaluate the assumptions and limitations inherent in models used to describe energy transformations. Encourage discussions on whether energy can be considered a tangible entity or simply a useful mathematical construct, and how different models shape our understanding of physical phenomena.
TOK: Real-World Applications: Explore real-world applications of energy concepts, such as renewable energy technologies or energy-efficient design, and prompt students to consider the role of scientific knowledge in addressing global challenges related to energy sustainability and climate change.
Practicals:</td></tr>
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<table>
<tr><td></td><td colspan="2">• Inclinded plane</td></tr>
<tr><td></td><td>Gravitational fields

Kepler's three laws, Newton’s law of gravitation

Gravitational potential energy, potential energy and the gravitational potential.

Escape speed, orbital speed</td><td>g considered as gravitational field strength,
g calculated from Newton’s law.
g regarded as the gravitational potential gradient.

Qualitative effects of drag forces due to the atmospheric drag forces.</td></tr>
<tr><td></td><td colspan="2">Practicals:

• Kepler’s second law using marbles in an elliptical frame</td></tr>
<tr><td></td><td>Simple harmonic motion

Parameters of harmonic motions, conditions for simple harmonic motions.

Period for string and spring pendulum.

Energy changes during one cycle of an oscillation.</td><td>HL:
• $v = \pm\omega\sqrt{x_o^2 - x^2}$
• $E_p = \frac{1}{2}m\omega^2 x^2$</td></tr>
<tr><td></td><td colspan="2">Practicals:

• Energy conservation for a spring pendulum
• String pendulum: is it really a harmonic oscillation?</td></tr>
<tr><td></td><td>Thermal energy transfer

Microscopic gas theory and it’s parameter, temperature scales, temperature gradient and heat transfer, phase changes

Conduction, convection, thermal radiation</td><td>Internal energy and potential
• $\overline{E_{kin}} = \frac{2}{2}k_B T$

Quantitative analysis of thermal radiation processes as electromagnetic wave, Boltzmann law, apparent brightness, emission spectrum of a black body using Wien’s</td></tr>
<tr><td></td><td colspan="2">Practicals:

• Heat capacity and latent heat of laten heat of evaporation.
• Determination of the temperature of a red glowing piece of copper.
• Mixing water an ice: Resulting temperature</td></tr>
<tr><td></td><td>Gas laws

Modelling a gas: ideal gas, pressure, gas laws, real gases,</td><td>• $P = \frac{1}{3}\rho v^2$
• internal energy of an ideal gas
• $U = \frac{3}{2}N k_B T$</td></tr>
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<tr><td></td><td></td><td>Temperature, pressure and density conditions under which a an ideal gas is a good approximation of a real gas.</td></tr>
<tr><td></td><td colspan="2">Practicals:
Boyle-Mariotte</td></tr>
<tr><td></td><td><h2>Greenhouse effect</h2>Not taught in our GPC</td><td>Emissivity, albedo, dependence of the albedo
Solar constant
incoming power = radiated power
Greenhouse gases
Absorption of IR and subsequent emission
Change of the greenhouse gases.</td></tr>
<tr><td></td><td colspan="2">Practical: Temperature change of various objects in the sun.
Practical: Temperature in a CO_2 atmosphere compared to regular air
TOK: Understanding Scientific Models: Discuss the nature of scientific models used to describe the greenhouse effect and climate change. Encourage students to critically evaluate the assumptions, simplifications, and uncertainties inherent in these models, as well as their predictive power and limitations. Explore how different models can lead to different conclusions and the implications of model selection for policy decisions.
TOK: Analyzing Data and Evidence: Engage students in discussions about the interpretation of data and evidence related to the greenhouse effect. Encourage them to critically evaluate the reliability, validity, and relevance of different sources of data, such as temperature records, ice core samples, and satellite observations, and to consider how scientific consensus is established and maintained in the face of uncertainty and disagreement.</td></tr>
<tr><td></td><td><h2>Current and circuits</h2>DC, voltage, amperage, electric resistance and its origin, Ohm’s law, Ohmic, series and parallel circuits.</td><td>Emf, Chemical cells,
Resistivity,
Internal resistance of electric cells.</td></tr>
<tr><td></td><td colspan="2">Practicals:
The resistance of a light bulb (temperature dependence)
Individual resistances obtafrom measuring equivalent resistances.</td></tr>
<tr><td></td><td><h2>Electric and magnetic fields</h2>Forces between charges, Coulomb’s law, conservation of charge, Millikan’s experiment, electrostatic induction, electric potential of a spherical object, electric field strength as the gradient of the potential, work, equipotential</td><td></td></tr>
</table>

	surfaces, relation between equipotential surfaces and field lines.	
	Practicals: • Measuring 2D equipotential lines of various charges	
	Motion in electromagnetic fields Motions in uniform electric and magnetic fields, parallel and perpendicular to the field lines. Lorentz force on a charge and a current-carrying conductor.	force per unit length between parallel wires as given by $\frac{F}{L} = \mu_0 \frac{I_1 I_2}{2\pi r}$
	Practicals: • e/m determination in a Teltron tube. • Trajectory of electrons in a vertical electric field.	
	Induction **Only HL** (covered in GPC) Magnetic flux, Faraday's law. Lenz's law. Connection between Lenz's law and energy conservation. Rotating coil in a uniform magnetic field.	
	Practicals: • Discharge of a capacitor • oscillating circuit	
	Wave model Transverse and longitudinal travelling waves; wavelength, frequency, time period, wave speed and their relationship; sound waves; electromagnetic waves; mechanical waves vs. electromagnetic waves	
	Practicals: • Wave speed on Snakey • Investigating multiple-slit diffraction	
	Wave phenomena	

	Wavefronts and rays; reflection, refraction and transmission; wavefront-ray diagrams; superposition of waves and wave pulses; path difference condition for constructive interference	Diffraction around a body and through an aperture; Snell´s law, critical angle, total internal reflection; coherence
	Practicals: • Determination of the refraction index	
	Standing waves and resonance Nature and formation of standing waves; nodes, antipodes, relative amplitude, phase difference; standing wave patterns in strings and pipes; resonance, natural frequency, driving frequency; effects of damping on maximum amplitude and resonant frequency; effect of the damping strength	Open and closed pipe, determination of wavelength and frequency of nth harmonic; impact of damping on frequency response; useful and destructive effects of resonance.
	Practicals: • Investigating speed of sound (interference with two loudspeakers) • Investigating resonance curves.	
	Doppler Effect	Doppler effect for sound waves and electromagnetic waves; representation in form of wavefront diagrams for moving source and moving observer, relative change of frequency, information about motion of stars and galaxies from shifts in spectral lines HL: formulas for moving source and moving observer.
	Practicals: • Investigating Doppler-effect (swinging sound-source)	
	Structure of the atom Geiger-Marsden-Rutherford-experiment, nuclear notation; emission/absorption spectra and atomic energy levels; photon emission and absorption; photon energy and energy level difference; angular momentum quantisation; Bohr energy levels for hydrogen.	HL: formula for nucleon radius; deviation of Rutherford scattering at high energies; instance of closest approach.
	• ***TOK: Historical Perspectives**: Discuss the historical development of atomic models, from ancient Greek philosophers to modern quantum theory. Encourage students to explore how cultural, societal, and technological factors influenced the evolution of atomic theory and the construction of knowledge in this area.*	

<table>
<tr><td></td><td colspan="2">• TOK: Comparing Models: Prompt students to critically compare and contrast different atomic models, such as the plum pudding model, the Bohr model, and the quantum mechanical model. Encourage them to consider how these models differ in their assumptions, predictive power, and explanatory scope, and how experimental evidence supports or challenges each model.

Practicals:

• Franck-Hertz Experiment
• Analysis of the aydrogen spectrum</td></tr>
<tr><td></td><td><h2>Quantum physics</h2>Photoelectric effect and Einstein‘s explanation, diffraction of particles (wave nature of matter), wave-particle duality, de Broglie wavelength.</td><td>Compton scattering including formula of wavelength shift.</td></tr>
<tr><td></td><td colspan="2">Practical:

• h-determination using the photo effect (inner & outer),
• determination of the wavelength via Debye-Scherer

• TOK: Different Views on Quantum Theory: Explain that scientists have different ways of understanding and explaining quantum theory. For example, some think quantum events happen randomly until observed (Copenhagen interpretation), while others believe every possible outcome happens in separate universes (Many-Worlds interpretation).
• TOK: Challenges in Understanding Quantum Experiments: Discuss that quantum experiments can be puzzling because they sometimes behave differently when observed. This raises questions about how much the observer influences the outcome and what happens at the smallest scales of reality.</td></tr>
<tr><td></td><td><h2>Radioactive decay</h2>Isotopes; nuclear binding effect; mass defect; mass-energy-equivalence; strong nuclear force; radioactive decay; changes in the state of nucleus; spectrum of alpha and gamma radiation; law of radioactive decay; activity; half-life and decay constant.</td><td>Spectrum of alpha and gamma radiation and their evidence or discrete nuclear energy levels; beta decay spectrum and neutrino.

Approximate constancy of binding energy curve above a nucleon number of 60.</td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td></td><td><h2>Fission</h2>Spontaneous and neutron-induced fission; chain reactions; nuclear power plant and its technicalities; products of nuclear fission and their management.</td><td></td></tr>
<tr><td></td><td><h2>Fusion and stars</h2></td><td>Black body radiation.</td></tr>
</table>

	Not taught in GPC	Stability of stars; fusion as energy source; fusion conditions (enmity and temperature); evolution of a star depending on the stellar mass; Hertzsprung-Russell-diagram; stellar parallax. determination of stellar radii.
	***Rigid body mechanics, only HL** **Not taught in GPC**	Torque force and rotational equilibrium/angular acceleration. Equations of motion for uniform angular acceleration. Moment of inertia and angular momentum and impulse. Kinetic energy of rotational motion.
	Practicals: • Filled and open cylinders with the same mass and dimensions roll down an inclined slope.	
	***Galilean and special relativity, only HL** Reference frames, Galilean relativity, two postulations of special relativity, Lorentz transformation, relativistic velocity addition. Proper time interval and proper length. Time dilation, length contraction. Muon decay as test for special relativity	Space-time interval Relativity of simultaneity. Space time diagrams and worldlines of objects moving with constant speed.
	***Thermodynamics, only HL** **Not taught in GPC**	Closed vs. Isolated systems First law of thermodynamics, work done on a closed system, change of the internal energy $Q = \Delta U + W \quad W = P\Delta V \quad \Delta U = \frac{3}{2} N k_B T$ Entropy $\Delta S = \frac{\Delta Q}{T}$ Second law of thermodynamics, irreversibility and Entropy increase. isovolumetric, isobaric, isothermal and adiabatic processes $pV^{\frac{5}{3}} = const$ Cyclic gas processes to run machines, in particular the Carnot cycle and its efficiency.

Group 4 Project:

The group 4 project takes place near the end of the first term of year one.

- Introduction: Students will discuss the overarching topic and find individual topics within the given topic.
- Planning and action phase: The students will plan and research their actions following the scientific method (research question, hypothesis, design of experiments, data collection, data processing, conclusion, evaluation)
- Experimental Phase: The students will complete their research and gather and pool their data.
- Analysis Phase: The students will analyze their data and their product and produce a(scientific poster/oral presentation).
- Presentation: The students present and discuss their collaborative results. Other interested students, teachers, and pre-IB-students may be invited to this session.
- Reflection: The students are encouraged to reflect on their personal skills in their reflective statement.

IB internal assessment requirement to be completed during the course

Students and their parents are rendered general information on internal assessments in all subjects within the IB Diploma Programme during the two years preceding the start of the first year. An overview of the topics covered and examples of former explorations are presented during an information session on all IB subjects three months before the start of the IB Diploma Programme. After the first quarter of the first year students are asked to mark an internal assessment from the support material. Each group marks the exploration according to one or two assessment criteria and prepares feedback and suggestions on how this particular piece of work could be improved. The assessment criteria, the reason for the marks awarded by the students and proposals for improvement are then presented and discussed in detail. All general hints, notes and advice are collected so that they can serve as guidance for the students´ own exploration. Ways to find appropriate topics, research questions and successful methods to handle these are discussed in class as well as safety, ethical and environmental factors. The requirements for academic integrity and the consequences of academic malpractice are being outlined as well.

Students are informed about how to use charts and diagrams, data tables, calculations, citation/reference, bibliography and formal aspects of the internal assessment. Within the practicals, the students do hands-on practical laboratory work, fieldwork, use spreadsheets, databases and simulations.

Students are provided with access to further material on the exploration on MS Teams or other platforms. Students decide on a topic after the third quarter and submit their first draft before the summer break. After getting feedback, students have two weeks to submit their final version in the first quarter of the second year.

Links to TOK – some examples of how links between the topics of physics and TOK are explored.

When introducing the concept of force, Aristotle‘s view and the way how to overthrow will be discussed. The so-called Oxford Calculators and their way of using mathematical methods to make scientific process are being discussed in class.
The problems, chances and consequences of the concept of „Absolute zero“ are being discussed in thermodynamics and field theory.
The nature of the concept „law“ will be discussed in several contexts, e.g. Ohm´s law.

Approaches to learning (ATL)

Here’s how ATL skills can be integrated into the study of electromagnetic induction in IB Physics:

Thinking Skills

- Critical Thinking: Students analyze the operation of different electromagnetic devices, such as transformers and electric generators. They evaluate the efficiency of these devices by calculating the power loss and identifying factors that affect their performance.
- Creative Thinking: Students design an innovative experiment to explore the relationship between the speed of a moving magnet and the induced electromotive force (emf) in a coil. They brainstorm various experimental setups and choose the most effective one.

Research Skills

- Information Literacy: Students conduct research on historical developments in the field of electromagnetic induction, such as Faraday's and Henry's experiments. They use academic databases, scientific journals, and reputable websites to gather accurate information.
- Data Analysis: Students collect and analyze data from their experiments on electromagnetic induction. For instance, they measure the voltage induced in a coil at different frequencies of magnetic field changes and use statistical tools to interpret their results.

Communication Skills

- Oral Communication: Students present their experimental findings on electromagnetic induction to the class, explaining the principles, methodology, and results clearly and concisely.
- Written Communication: Students write detailed lab reports that include an introduction to the theory of electromagnetic induction, their experimental procedure, data analysis, and conclusions. They use proper scientific terminology and formatting.

Social Skills

- Collaboration: Students work in groups to design and build a simple electric generator. Each group member takes on a specific role, such as researching materials, constructing the device, or analyzing the results. They share their findings and provide constructive feedback to one another.
- Teamwork: During group experiments, students discuss their observations and hypotheses, ensuring that everyone contributes to the analysis and interpretation of data.

Self-Management Skills

- Time Management: Students create a project timeline for their investigation into electromagnetic induction, setting deadlines for research, experimentation, data analysis, and report writing. They use tools like calendars and project management apps to stay on track.
- Reflection: After completing their study of electromagnetic induction, students reflect on their learning process, identifying strengths and areas for improvement. They consider how well they managed their time and resources and how they might approach similar tasks in the future.

Links to CAS

High-achieving students in Physics who are in the IB Diploma Programme at our school offer a wide range of support services for lower-achieving students. For example, individual tutoring is offered for younger pupils. Moreover, as part of their CAS activities, students organised a weekly maths club for younger students who have difficulties in this subject. IB Diploma candidates also support teachers in Physics in our international classes to help immigrant children.
Furthermore, IB physics students support mathematical competitions that are held at our school and help assessing the work of younger students. In addition, some students also get actively involved in promoting excellence in mathematics at our school and the so-called „research club“ for younger students.
Many of our IB Diploma candidates are also members of the student council, where, in addition to calculating the costs of events, the creation and evaluation of surveys plays an important role. This is also relevant in some of the clubs offered at our school. For example, a survey was conducted and statistically analysed by IB students who were members of the school´s Fairtrade Club. They had campaigned for the sale of Fairtrade products in the school's own kiosk and evaluated how these products were accepted by the student body.

International mindedness

An example of a topic which contributes to international mindedness

The universal language of physics can be seen as a common and therefore international language that is understood by people all over the world. Physics fosters and supports the further development and discovery of knowledge in a wide variety of fields and disciplines all over the world. Two notable examples of this phenomenon are the Large Hadron Collider (LHC) at CERN and the Global Positioning System (GPS).

The Large Hadron Collider, located at CERN (the European Organization for Nuclear Research) near Geneva, Switzerland, is a prime example of international collaboration in physics. As the world's largest and most powerful particle accelerator, the LHC is designed to explore fundamental questions about the universe, such as the origin of mass and the nature of dark matter. The construction and operation of the LHC involve the participation of thousands of scientists, engineers, and technicians from over 100 countries. This collaborative effort is not merely a pooling of resources but a true integration of diverse expertise and perspectives. For instance, the discovery of the Higgs boson in 2012, which confirmed the existence of the Higgs field that gives particles their mass, was the result of meticulous work by a global community of physicists. The LHC exemplifies international mindedness by fostering a sense of shared purpose among scientists worldwide. Regardless of their nationalities, these individuals work together to push the boundaries of human knowledge. This spirit of cooperation transcends political differences, promoting a culture of peace and mutual respect. Furthermore, the results of their research are shared openly with the global scientific community, ensuring that the benefits of their discoveries are universally accessible.

Another illustration of international mindedness in physics is the Global Positioning System (GPS). Originally developed by the United States Department of Defense for military purposes, GPS has evolved into a critical tool for civilian use worldwide. It relies on a constellation of satellites that provide geolocation and time information to a GPS receiver anywhere on Earth. The physics behind GPS involves principles of relativity and precise atomic clocks. The accurate functioning of this system depends on the synchronization of these clocks with the ones on Earth, taking into account the effects of general and special relativity. The application of these advanced concepts in a global framework highlights the universality of physical laws and their relevance to everyday life. GPS's contribution to international mindedness lies in its ubiquitous application and the international cooperation it necessitates. Countries around the world rely on GPS for navigation, communication, and various forms of infrastructure management. This reliance on a system initially developed by a single nation underscores the interconnectedness of modern societies. Furthermore, efforts to develop complementary or alternative systems, such as the European Union's Galileo, Russia's GLONASS, and China's BeiDou, illustrate a global commitment to enhancing and diversifying this critical technology. The widespread use of GPS fosters a shared understanding of scientific principles and their practical applications. It also underscores the importance of international cooperation in maintaining and advancing global systems that benefit all of humanity. By relying on a common technological infrastructure, nations are encouraged to work together, thereby reinforcing the interconnected nature of the modern world.

The examples of the Large Hadron Collider and the Global Positioning System underscore how physics promotes international mindedness through collaborative efforts and universal applications. These endeavors highlight the collective nature of scientific inquiry and the shared benefits of technological advancements. In a world often divided by national interests, the field of physics serves as a reminder of our common quest for knowledge and the profound impact of international cooperation. Through projects like the LHC and technologies like GPS, physics continues to bridge cultural and political divides, fostering a sense of global unity and mutual understanding.

Development of the IB learner profile

An example of how the contents and related skills of one topic pursue the development of the attributes.

The IB Learner Profile attributes can be effectively integrated into the study of electromagnetic induction in IB Physics, enriching the learning experience and helping students develop both subject-specific knowledge and broader skills. Here’s how various attributes of the IB Learner Profile can be applied to this topic:

Inquirer: Students embodying the "Inquirer" attribute demonstrate curiosity about how electromagnetic induction works and its applications in real-world scenarios. Students could investigate the principles of electromagnetic induction by exploring how electric generators and transformers operate. They might start with a research question such as, "How does the number of coils in a transformer affect its efficiency?" They could then design experiments, conduct simulations, and analyze their findings, fostering a deep and sustained interest in the topic.

Knowledgeable: Students develop a comprehensive understanding of electromagnetic induction, its principles, and its applications. Students could create detailed presentations or reports on the key concepts of induction, including Faraday's Law, Lenz's Law, and the functioning of devices like inductors, generators, and transformers. They would connect these concepts to real-world applications such as power generation and wireless charging technologies, demonstrating their in-depth understanding.

Thinker: Students apply critical thinking skills to solve complex problems related to electromagnetic induction. Students might be given a complex problem to solve, such as designing an efficient wind turbine generator. They would need to apply their knowledge of induction to optimize the number of coils and the strength of the magnetic field. They would use logical reasoning and mathematical calculations to predict the performance of their design and propose improvements based on their analysis.

Communicator: Students effectively communicate their understanding of electromagnetic induction and collaborate with peers to enhance learning. Students could work in groups to build and test simple electromagnetic devices, such as a small generator. They would then present their findings to the class, explaining the principles of operation and the results of their experiments. This activity would involve clear communication of scientific ideas and collaborative problem-solving.

Principled: Students act with integrity and honesty in their scientific investigations related to induction. While conducting experiments, students maintain accurate and honest records of their observations and data. They acknowledge any errors or uncertainties in their results and ensure that their reports and presentations credit all sources and collaborators appropriately.

Open-Minded: Students appreciate the contributions of different cultures and viewpoints in the development of electromagnetic theory and technology. Students could explore the historical development of electromagnetic induction, recognizing the contributions of scientists from various backgrounds, such as Michael Faraday and Joseph Henry. They might also examine how different countries use induction technologies in unique ways and discuss the global impact of these technologies.

Caring: Students consider the ethical implications and societal impact of technologies based on electromagnetic induction. Students could debate the benefits and drawbacks of widespread induction-based technologies, such as their use in renewable energy generation versus the environmental impact of producing and disposing of electronic components. They would demonstrate empathy and consideration for different perspectives, aiming to propose solutions that benefit society as a whole.

Risk-Takers: Students are willing to experiment with new ideas and approaches in their study of induction, even if they are uncertain about the outcomes. Students might design and carry out innovative experiments that explore less common applications of induction, such as magnetic levitation or induction heating. They would approach these tasks with courage and independence, learning from both their successes and failures.

Balanced: Students understand the importance of balancing different aspects of their lives to maintain well-being while engaging in intensive study. While working on a challenging project related to induction, students ensure they manage their time effectively, balancing their academic responsibilities with other activities and self-care practices. They reflect on how maintaining this balance helps them perform better academically and personally.

Reflective: Students thoughtfully consider their learning experiences and the impact of their studies on their understanding of the world. After completing a unit on electromagnetic induction, students write reflective essays on what they have learned, how their understanding has evolved, and how they can apply this knowledge in the future. They might also reflect on the challenges they faced and how they overcame them, considering what they might do differently next time.

Research skills

Apart from the necessary skills like literature search the physics course requires the ability to obtain, analyse and process data and to graphically present the obtained results. Obtaining experimental data requires diligence and thoroughness. Many of these skills require the use of computers. In the SL we use standard spreadsheet and publishing programs. Interested students can use Jupyter-lab and Latech.

Time management

Especially during the IA and during the group 4 project, the students depend heavily on their time management skills. We help them develop these skills by providing them with a time schedule for these works on the background of the school year and by giving them examples how such time schedules were met and not met during past IA and group 4 works. We outline typical pitfalls concerning the IA planning and process, such as doing the initial measurements too late, not taking enough time for repeat measurements at an early stage, not considering measurement and data quality early on. We provide the students with the IA requirements early on and expect the IAs to be finished by the end of the first year. After regular timespans, we let them present their progress to their fellow students and give feedback on where they stand. The same principles are being applied to the group 4 project as well.

Last reviewed: June 2024