Diplomा Programme subject outline—Group 4: sciences			
School name	Goetheschule Essen	School code	003511
Name of the DP subject *(indicate language)*	Physics		
Level *(indicate with X)*	Higher: X; Standard completed in two years: X; Standard completed in one year *:		
Name of the teacher who completed this outline	Dr. Robert Paternoga	Date of IB training	June 25-28, 2014
Date when outline was completed	January, 2023	Name of workshop *(indicate name of subject and workshop category)*	IBDP Physics, Category 2

* All Diploma Programme courses are designed as two-year learning experiences. However, up to two standard level subjects, excluding languages ab initio and pilot subjects, can be completed in one year, according to conditions established in the *Handbook of procedures for the Diploma Programme*.

1. Course outline

– Use the following table to organize the topics to be taught in the course. If you need to include topics that cover other requirements you have to teach (for example, national syllabus), make sure that you do so in an integrated way, but also differentiate them using italics. Add as many rows as you need. Topics which may be relevant for IB students are *italized*, all others which are relevant for the national syllabus only are written in normal fonts.

– This document should not be a day-by-day accounting of each unit. It is an outline showing how you will distribute the topics and the time to ensure that students are prepared to comply with the requirements of the subject.

– This outline should show how you will develop the teaching of the subject. It should reflect the individual nature of the course in your classroom and should not just be a “copy and paste” from the subject guide.

– If you will teach both higher and standard level, make sure that this is clearly identified in your outline. Topics taught to HL students, and time allocated exclusively to these studens, are marked in red. Practical work and allocated time is marked in blue, while additional practical work for HL students is in purple.

– Since our German abitur consists of three years, instead of two, we have the time comfort to teach some of the topics which have to be covered for IB students in one additional first year. Each German physics student has to participate in this pre-IB physics course, which I have denoted as “Year 0” in the syllabus.

	Topic/unit (as identified in the IB subject guide) *State the topics/units in the order you are planning to teach them.*	Contents	Allocated time One class **45** minutes. In one week **3** classes.	Assessment instruments to be used	Resources *List the main resources to be used, including information technology if applicable.*
Year 0	1. Measurement and uncertainties 1.1 Measurements in physics 1.2 Uncertainties and errors 1.3 Vectors and scalars	*Fundamental and derived SI units,* *scientific notification and metric multipliers,* *uncertainties and errors,* *vectors and scalars* *practicals:* *Hooke's Law* *String Pendulum*	12 classes (9 h) + 6 classes (4.5 h)	The internal assessment consists of the practical scheme of work (PSOW) and the interdisciplinary project (see group 4-project). See also aspects of the external assessment in year 2. Apart from these assessments the students will also take three written exam papers in this first pre-IB physics course.	Cornelsen: Oberstufe Gesamtband Physik, 2008, distributed to all students
	2. Mechanics 2.1 Motion 2.2 Forces 2.3 Work, energy and power 2.4 Momentum and impulse	*Motion:* *displacement, velocity, acceleration, motion graphs, projectile motion* *Forces:* *free body diagrams, Newton's laws, solid friction* *conservation of momentum, collisions* *Work, energy, power: kinetic and potential energy, conservations of energy, power and efficiency* *Bouncing ball* *Friction*	48 classes (32 h) + 6 classes (4.5 h)		

	6. Circular motion and gravitation 6.1 Circular motion 6.2 Newton's law of gravitation	*Circular motion:* *period, frequency angular displacement and speed,* *centripetal force and acceleration* *Gravitational field and orbits:* *Newton's law of gravitation,* *gravitational field and gravitational field strength*	32 classes (24 h)		
	A. Relativity A.1 The beginning of relativity	*The beginnings of relativity:* *Reference frames, Galilean relativity and Einstein's, The constancy of the speed of light,* *time dilation, moving vertical clock with two mirrors*	12 classes (8 h)		

	Topic/unit (as identified in the IB subject guide) *State the topics/units in the order you are planning to teach them.*	Contents	Allocated time One class: 45 minutes. In one week: 5/7 classes.	Assessment instruments to be used	Resources *List the main resources to be used, including information technology if applicable.*
Year 1	**4. Waves** 4.1 Oscillations 4.2 Travelling waves 4.3 Wave characteristics	*Oscillations:* *Time period, frequency, amplitude, displacement, phase, conditions for simple harmonic motion,*	32 classes (24 h)	Throughout the remaining 2 year course, there will be eight exam papers which will cover most topics	IB Physics Stugy Guides, 2014, Oxford, Distributed to all IB students

	4.4 Wave behavior 4.5 Standing waves	*conversion of energy* *Waves and wave behaviour:* *Travelling waves, Wavelength, frequency, period, wave speed, transverse and longitudinal waves, Amplitude and intensity, superposition, polarization, standing waves, boundary conditions, nodes and anitnodes,* Differential equations *Practicals:* *Snell's refraction law*	 +4 classes (3 h)	(reference "German curriculum"). The resulting grades will count towards the final grade of the German abitur. The exam topics cover relevant IB topics and therefore also serve as regular and detailed feedback for our students.	IB Questionbank Physics: Prepared test questions for specific topics
	9. Wave phenomena 9.1 Simple harmonic motion 9.2 Single-slit diffraction 9.3 Interference 9.4 Resolution 9.5 Doppler effect	*Simple harmonic oscillations, energy changes, Wavefronts and rays, reflection and refraction, Snell's refraction law, critical angle and total internal reflection, single-slit diffraction, double-slit and multiple-slit interference, path difference* mathematical descriptions of waves *Resolution of diffraction gratings, Size of diffracting aperture, Thin film interference, Doppler effect for moving source and moving observer* *Practicals:* *Jelly*	36 classes (27 h) 24 classes (18 h) +4 classes (3 h)		
	5. Electricity and magnetism 5.1 Electric fields 5.2 Heating effect of electric currents 5.3 Electric cells	*Charge and current, electric field strength, electrid field lines, Coulomb's law, potential difference heating effect of electric current, resistivity, electric cells, magnetic effects of electric currents,*	40 classes (30 h)		

	5.4 Magnetic effect of electric current	*diodes, rectification* Magnetic field of solenoid and single conductor *Practicals:* *Ohm's Law* *Electric cells*	 +6 classes (4.5 h)		
	10. Fields 10.1 Describing fields 10.2 Fields at work	*Comparison of the eletrostatic field, magnetic field and gravitations field, Concept of field lines, field strength, Potential and equipotential lines and surfaces, potential energy, gradient, Escape speed, Orbital motion gravitational force vs. coulomb force* *Practicals:* *Magnetic balance* *Electromagnets*	24 classes (18 h) +6 classes (4.5 h)		
	11. Electromagnetic induction 11.1 Electromagnetic induction 11.2 Power generation and transmission 11.3 Capacitance	*Electromotive forces, Faraday's law of induction for changes of magnetic field strength and area changes, magnetic flux, Lenz's law, alternating current, generators, transformers, rms values of current and voltage, energy transport, Capacity of a parallel-plate capacitor, dielectrica, capacitors and resistors parallel and in series, RC-circuits, time constant,* RL-, LC- and LCR-circuits, differential equations, Hertzian dipole, generation of electromagnetic waves *Practicals:*	28 classes (21 hours) 28 classes (21 hours) +8 classes (6 h)		

		Transformers *Discharging a capacitor*			
		Group-4-Project	13 classes (10 h)		
		Individual Investigation	13 classes (10 h)		

Year 2	**12. Quantum and nuclear physics** 12.1 The interaction of matter with radiation 12.2 Nuclear physics	*The photoelectric effect, concept of photon,* x-ray tube and x-ray spectra Diffraction of electrons, *matter waves, wavefunctions and probability distributions, double-slit experiment with electrons, Rutherford experiment, Bohr model for hydrogen, quantization of angular momentum,* characteric x-ray spectra*,* Franck-Hertz-experiment, *pair produciton and annihilation,* *nuclear energy levels, beta-decay and neutrinos, law of radioactive decay,* *tunneling effect,* *Heisenberg's uncertainty principle*	40 classes (30 h) 24 classes (18 h)	The external assessment, which is required by the IBO, consists of three written papers. Paper 1: 30 multiple-choice questions (Duration: 3/4 hour, Weighting: 20%) Paper 2: (1¼ hours, 40%) Short-answer and extended-response questions Paper 3: (1 hour, 20%) one data-based question and several short-answer questions on experimental work, short-answer and extended-response questions chosen from one option.	
	7. Atomic, nuclear and particle physics 7.1 Discrete energy and radioactivity 7.2 Nuclear reactions 7.3 The structure of matter	*Discrete energy and the interaction of matter with radiation:* *Discrete energy and discrete energy levels, transitions between energy levels* *Properties of the nucleus and radioactivity:* *Radioactive decay, alpha particles, beta particles, gamma rays, half-life, absorption characteristics of decay*	40 classes (30 h)		

		particles, isotopes, background radiation, the unified atomic mass unit, mass defect and nuclear binding energy, nuclear fission and nuclear fusion *The structure of matter:* *Quarks, leptons and their particles, hadrons, mesons and baryons, the conservation laws of charge, baryon number, lepton number and strangeness, the nature of range of the strong nuclear force, weak nuclear force, electromagnetic force, exchange particles, Feynman diagrams, confinement, the Higgs boson*			
	3. Thermal physics 3.1 Thermal concepts 3.2 Modelling a gas	*Mole, molar mass, Avogadro constant, internal energy, absolute temperature, specific heat capacity, phase change, specific latent heat* *Modelling a gas: ideal gas, pressure, gas laws, real gases* *Practicals:* *Specific heat capacity of water* *Gas law* *Coffee and milk*	16 classes (12 h) + 6 classes (4.5 h) + 6 classes (4.5 h)		
	8. Energy production 8.1 Energy sources 8.2 Thermal energy transfer	*Energy sources:* *specific energy, energy density of fuel sources, Sankey diagrams, primary energy sources, electricity as a secondary versatile form, renewable and non-renewable energy sources* *Global thermal energy transfer: black body radiation, Albedo and emissivity, solar constant, greenhouse-effect, energy*	12 classes (9 h)		

		balance in Earth surface - atmosphere system			
	A. Relativity A.2 Lorentz transformations A.3: Spacetime diagrams	*Maxwell's equations, The constancy of the speed of light, forces on a charge or current* *Lorentz transformations:* *The two postulates of special relativity, clock synchronization, the Lorentz transformations, velocity addition, invariant quantities, time dilation, length contraction, the muon decay experiment* *Spacetime diagrams:* *Spacetime diagrams, world lines, the twin paradoxon* *Practicals:* *The speed of light*	20 classes (15 h) +2 classes (1.5 h)		
	A,4: Relativistic mechanics A.5: General relativity	*Relativistic mass, momentum and energy, equivalence of mass and energy, decribing particle masses and momentums in terms of eV, photons, particle acceleration* *General relativity:* *equivalence principle, gravitational time dilation,* *black holes, schwarzschild geometry, bending of light, event horizon, gravitational redshift, pound-rebka experiment, cosmology*	15 classes (12 h)		

2. The Group 4 Project

As the IB guides say, “The group 4 project is a collaborative activity where students from different group 4 subjects work together on a scientific or technological topic, allowing for concepts and perceptions from across the disciplines to be shared in line with aim 10—that is, to ‘encourage an understanding of the relationships between scientific disciplines and the overarching nature of the scientific method.’” Describe how you will organize this activity. Indicate the timeline and subjects involved, if applicable.

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

The students choose a main topic that allows them to carry out interdisciplinary investigations. Main topics may be, for example, bionics, food, resilience, walking on water, etc.. In a first pre-group 4 session the students are requested to search this topic by themselves.

Timeline

1. **Introduction:** Students will discuss the umbrella topic and find individual topics within the given topic.
2. **Planning and action phase:** The students will plan and research their actions following the scientific method (research question, hypothesis, design of an experiment, data collection, data processing, conclusion, evaluation)
3. **Action Day:** The students will complete their research and gather and pool their data.
4. **Evaluation Day:** The students will evaluate their data and resources used to produce a display product (*scientific poster* and oral presentation).
5. **Presentation:** The students present and discuss their collaborative results. Other interested students, teachers, and pre-IB-students may be invited to this session.
6. **Reflection:** The students are encouraged to reflect on their *personal skills* in their reflective statement.

3. IB practical work and the internal assessment requirement to be completed during the course

As you know, students should undergo practical work related to the syllabus.

- Physics, chemistry and biology: 40 hours (at standard level) or 60 hours (at higher level)
- Computer science: 40 hours (at standard level) or 40 hours (at higher level)
- Design technology: 60 hours (at standard level) or 96 hours (at higher level)

- Sport, exercise, and health science: 40 hours (at standard level) or 60 hours (at higher level)

The internal assessment, worth 20% of the final grade, includes one individual investigation (about 10 hours and a write-up about 6 to 12 pages long) with the five assessment criteria of personal engagement (8%), exploration (25%), analysis (25%), evaluation (25%) and communication (17%).

At the very beginning of year one, the students are going to receive a handout to introduce them to the internal assessment requirement. They are encouraged to frame their individual investigation until end of March. The individual investigation consists of conducting and evaluating an experiment on an arbitrary topic from the IB syllabus. Students must then apply their knowledge of measuring and uncertainties. To conduct the experiment, students are encouraged to use the school's laboratories.

They have to hand in the first draft by the end of May. They are given feedback. The deadline of the final draft is typically set in autumn of the second year. If the students have to write individual investigations in two group four subjects, the deadlines for the different stages of the second investigation are postponed by 2-4 weeks.

Use the table below to indicate the name of the experiment you would propose for the different topics in the syllabus.

An example is given. Add as many rows as necessary.

Name of the topic	**Experiment**	**Any ICT used?** *Remember you must use all five within your programme.*
Acids and bases	Titration	Yes
2. Mechanics	Hooke's Law	Graph plotting software
2. Mechanics	String Pendulum	Data logging / Graph plotting software
2. Mechanics	Bouncing Ball	Spreadsheet
2. Mechanics	Friction	Database
4. Waves	Snell's Refraction Law	

9. Wave Phenomena	Jelly	
5. Electricity and Magnetism	Ohm’s Law	
5. Electricity and Magnetism	Electric Cells	
10. Fields	Magnetic Balance	
10. Fields	Electromagnet	
11. Electromagnetic Induction	Transformers	
11. Electromgnetic Induction	Discharging a Capacitor	Computer simulation
3. Thermal Physics	Specific Heat Capacity of Water	
3. Thermal Physics	Gas Laws	
3. Thermal Physics	Coffee and Milk	
A. Relativity	The Speed of Light	

4. Laboratory facilities

Describe the laboratory and indicate whether it is presently equipped to facilitate the practical work that you have indicated in the chart above. If it is not, indicate the timeline to achieve this objective, and describe the safety measures that are applicable.

There is adequate instructional space for any of the practical work mentioned above. We have two classrooms which are equipped with lab benches. There are sinks next to each lab bench and adequate cabinet space to store laboratory equipment and supplies. All lab benches have gas connections and different electrical sockets. Each lab bench is big enough for 2-4 students doing their practicals and the rooms are equipped with projectors that can be connected to computers and data logging devices. During this year, the older beamers will be replaced by modern laser beamers.

The science laboratories have the basic equipment and data logging devices for all experiments described in section 3.

Our school has **two** large physics collection rooms located in a rather new scientific extension building, so the facilities and furnishings are extraordinary compared with other German schools. With the help of an association called "Förderverein der Goetheschule Essen", we had the opportunity to buy lab equipment that other public German schools would not have, i. e. x-ray-tubes and different radioactive emitters.

Safety equipment: Goggles and gloves can be provided for individual student use. An eyewash station and a first-aid kit are available in each room. Fire extinguishers are located in every room and a fire blanket is available. Different safety switches in each room can be used to disconnect equipment quickly from gas and electricity. Acids, bases, and other chemicals are kept safe in lockable cabinets, as well as our radioactive emitters.

5. Other resources

Indicate what other resources the school has to support the implementation of the subject and what plans there are to improve them, if needed.

Recently, each student was equipped with a school iPad ,so lab data may now be collected more easily and processed at once.

6. Links to TOK

You are expected to explore links between the topics of your subject and TOK. As an example of how you would do this, choose one topic from your course outline that would allow your students to make links with TOK. Describe how you would plan the lesson.

Topic	Link with TOK (including description of lesson plan)
Quantum and nuclear physics	Double-slit experiment : Students know the double-slit experiment from laser light experiments, where maxima and minima were explained by wave properties of light and constructive and destructive interference. In quantum mechanics, the same pattern is then obtained for electrons, which behave like waves in this experiment. So what are electrons? Do they have any extension like waves or are they located at a single point? How can one electron interfere with itself if it is located at one point ? How can atoms build up a solid body if they consist of nothing else than points and vacuum? Moreover, how can all humans and how can the whole universe be made of this emptiness? By asking all these questions and reflecting on them, the students become aware of how the picture of our world is created by our mind, models, constructions and theories and that even the notion of reality is just a construction of our brains, whilst reality itself may exist, or not, we will never know.

7. Approaches to learning

Every IB course should contribute to the development of students' approaches to learning skills. As an example of how you would do this, choose one topic from your outline that would allow your students to specifically develop one or more of these skill categories (thinking, communication, social, self-management or research).

Topic	Contribution to the development of students' approaches to learning skills (including one or more skill category)
Energy production	Depending on the number of students, the course is divided into different expert groups. These expert groups focus on different energy resources and the associated types of power plants. The students have to read for comprehension and information, skim texts to build understanding, and have to prepare a presentation of their chosen source of energy. They have to collect arguments concerning the society, the pollution of the environment, the climate change, if their technologies are sustainable, etc. They manage and resolve problems, work collaboratively in teams, clarify difficult points, help each other and then prepare and rehearse the presentation they are going to give. After preparing this short presentation, new groups are mixed in such a way that experts from different groups come together. They present facts, advantages, and disadvantes of their specific energy resources to the other members of the groups. Therefore, they have to structure their information, encourage others to contribute, give and receive meaningful feedback and even advocate for one's own rights and needs. The other group members ask questions and they all discuss their results. The students use speaking techniques and media to communicate with one another, draw conclusions, and negotiate ideas with peers. Having heard each expert of the group the students discuss in full the advantages and disandvantages of the various sources of energy . They summarise their findings to find out the best concepts of energy production with respect to all the different aspects which have to be considered.

8. International mindedness

Every IB course should contribute to the development of international-mindedness in students. As an example of how you would do this, choose one topic from your outline that would allow your students to analyse it from different cultural perspectives. Briefly explain the reason for your choice and what resources you will use to achieve this goal.

Topic	Contribution to the development of international mindedness (including resources you will use)
Greenhouse Effect	The greenhouse effect is a global problem which incontrovertibly contributes to global warming and climate change. Greenhouse gases are made responsible for this effect, and emissions must be controlled and then reduced. Many poor people living in developing countries are seriously affected by the negative impacts of climate change. How may the emission of greenhouse gases, as well as the social injustice, be reduced?

	Resources: IB course book, [Overview of Greenhouse Gases | US EPA] [CO2 emissions - Our World in Data]

9. Development of the IB learner profile

Through the course it is also expected that students will develop the attributes of the IB learner profile. As an example of how you would do this, choose one topic from your course outline and explain how the contents and related skills would pursue the development of any attribute(s) of the IB learner profile that you will identify.

Topic	Contribution to the development of the attribute(s) of the IB learner profile
Atomic, nuclear and particle physics	In studying nuclear physics, different IB Learner Profile attributes can be acquired by students. First, the students need to be **Inquirers** because they want to find out about the nature of radioactive radiation, that they have may surely have heard about but which is something they cannot feel, see or smell. They will find out that knowledge about radioactive radiation is important and relevant for them, because it is dangerous for their health (**Knowledgeable**). When they carry out experiments, in order to learn about the law of radioactive decay, they will have to be confident enough to make predictions (**Risk-takers**) critical enough to analyse and prove their results (**Reflective**). When they discuss about how to deal with the radioactive waste and debate over nuclear power stations, the students act as **Communicators** to present their ideas and opinions to each other. In the discussion about nuclear energy as a safe and environmentally sustainable source of energy, the students will hopefully acquire a well-balanced view on a complex problem (**Balanced**).