Schola Europaea / Office of the Secretary-General

Pedagogical Development Unit

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Physics Syllabus – S4-S5

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1. General Objectives

The European Schools have the two objectives of providing formal education and of encouraging pupils' personal development in a wider social and cultural context. Formal education involves the acquisition of competences (knowledge, skills and attitudes) across a range of domains. Personal development takes place in a variety of spiritual, moral, social and cultural contexts. It involves an awareness of appropriate behaviour, an understanding of the environment in which pupils live, and a development of their individual identity.

These two objectives are nurtured in the context of an enhanced awareness of the richness of European culture. Awareness and experience of a shared European life should lead pupils towards a greater respect for the traditions of each individual country and region in Europe, while developing and preserving their own national identities.

The pupils of the European Schools are future citizens of Europe and the world. As such, they need a range of competences if they are to meet the challenges of a rapidly-changing world. In 2006 the European Council and European Parliament adopted a European Framework for Key Competences for Lifelong Learning. It identifies eight key competences which all individuals need for personal fulfilment and development, for active citizenship, for social inclusion and for employment:

1. Literacy competence;
2. Multilingual competence;
3. Mathematical competence and competence in science, technology and engineering;
4. Digital competence;
5. Personal, social and learning to learn competence;
6. Civic competence;
7. Entrepreneurship competence;
8. Cultural awareness and expression competence.

The European Schools' syllabi seek to develop all of these key competences in the pupils.

2. Didactical Principles

The didactical principles of the European Schools are formulated in the teaching standards of the European Schools (ref: 2012-09-D-11-en-4). For delivery the teaching standards state that the teacher:

- Uses teaching skills and creativity to inspire and motivate pupils
- Delivers well-structured lessons
- Makes an effective use of teaching time
- Employs a variety of teaching and learning methods, including technology, appropriate to the content
- Motivates pupils to be actively involved in their own learning
- Demonstrates good subject and curriculum knowledge including their national and European dimensions

The eight competences for physics are knowledge, comprehension, application, analysis, experimental work, digital competences, communication and team work.

To teach the competences for physics according to the teaching standards of the European Schools an inquiry-based approach to teaching and learning is strongly recommended in S4 - S5. The learning objectives listed in this syllabus, especially the competences concerning experimental work, digital and information competency, communication and team work cannot be achieved without a large focus on practical work.

3. Learning Objectives

Learning is not just getting more content knowledge. With learning in school, content is used to give the pupils competences to be prepared for society and work. Learning objectives for student performance therefore arise out of three dimensions: the European Framework for Key Competences for Lifelong Learning outlined in section 1, the academic competences outlined in 3.1 and the Cross-cutting concepts (Interdisciplinary Connections) in 3.2. This way we hope that the pupils will become prepared to a lifelong learning.

3.1. Competences

	Competency	Key Concepts
1.	**Knowledge**	The student displays a comprehensive knowledge of facts
2.	**Comprehension**	The student displays a thorough command and use of concepts and principles in science
3.	**Application**	The student makes connections between different parts of the syllabus and applies concepts to a wide variety of unfamiliar situations and makes appropriate predictions
4.	**Analysis**	The student is capable of detailed and critical analysis and explanations of complex data
5.	**Experimental work**	The student can formulate hypotheses and plan and carry out investigations using a wide range of techniques while being aware of ethical issues
6.	**Digital and information Competences**	The student can consistently and independently find and assess the reliability of information on scientific subjects, on- and offline and can independently use appropriate software for science tasks
7.	**Communication (oral and written)**	The student can communicate logically and concisely using correct scientific vocabulary and demonstrates excellent presentation skills
8.	**Teamwork**	The student works well in a team

3.2. Cross-cutting concepts

The list of cross cutting competences places the learning objectives within a larger context which i. e. can form the basis of a cross-curricular projects. The tentative list to be taught is based on the next generation science standards in the United States (National Research Council, 2013):

	Concept	Description
1.	**Patterns**	Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them
2.	**Cause and effect**	Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering
3.	**Scale, proportion and quantity**	In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change
4.	**Systems and system models**	Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding the world. Often, systems can be divided into subsystems and systems can be combined into larger systems depending on the question of interest
5.	**Energy and matter**	Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behaviour
6.	**Structure and function**	The way an object is shaped or structured determines many of its properties and functions
7.	**Stability and change**	For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand

4. Content

4.1 Topics

In S4 - S5 the material is structured by topic so that relevant content and competences are acquired at depth as well as in breadth. The material from S1 to S3 is expected to be known in S4 and will only be briefly repeated at the introduction of each topic.

Students in S4 - S5 must decide at the end of S5 if they wish to continue studying physics in S67. Statistics show that for most of them, S5 will be the final year of physics. Teaching and learning must address both groups.

The students, as citizens, should later be able to discuss and decide about items which are associated with physics. Therefore, it is strongly recommended that the students undertake one project each year linked to aspects of social issues (see attainment descriptors). There are suggestions for projects in the fourth column.

It is recommended that physics and mathematics teachers coordinate their teaching order to help the students address the mathematics needed for science subjects (see assessment part).

Topic	S4	S5
Electricity / Magnetism	x	
Mechanics	x	x
Waves	x	
Matter and Heat		x
Atomic and Nuclear Physics		x

There are six different symbols in the following content part, which indicate the areas:

	Activity
	Extension
	Phenomenon
	History
	Cross-Cutting Concepts
	Digital Competence

These icons highlight different areas and are used to make the syllabus easier to read. These areas are based on the key competences mentioned in section 1 of this document.

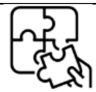
4.2 The tables

- **Year S4**

YEAR S4	**TOPIC: Electricity**	Pre-knowledge: S3 science introduces isolators and conductors. S3 science already teaches the behaviour of current and voltage in circuits. The relationship between energy, power and time, and kWh ~~is~~ are already taught in S3 science.	
Subtopic	**Content**	**Learning objectives**	**Key contexts, phenomena and activities**
Properties of DC Circuits	Electricity introduced as a versatile means of transferring energy	**Set up experiments** to test Ohmic and non-Ohmic components on how the current through them varies with potential difference and **analyse** the graphs for resistance	Determining resistance with a simple circuit
	Introduce the Coulomb as the SI unit for measuring the quantity of charge		Work together with Chemistry on the explanation of conductivity for different materials, for example by doing experiments and explaining by different models
	The idea of current as charge flow per unit time is introduced		
	The idea of voltage as energy per coulomb is introduced		
Circuits	Series and parallel circuits	**Apply** the principle of conservation of current to **calculate** (now with formulas) currents within circuits	Experiment to verify calculations made with circuits about current, voltage and resistance
		Determine how voltage is divided in circuits	Experiments to draw $U \to I$ graphs for examples of Ohmic and non-Ohmic components
	Resistance: $R = \frac{U}{I}$	**Calculate** potential difference or current or resistance from $R = \frac{U}{I}$	Use of applets to construct circuits from schema's and possibly check them in an experiment
	Rules of current, potential difference and total resistance in circuits: ▸ Series: • $I_{tot} = I_1 = I_2 = \cdots;$ • $U_{tot} = U_1 + U_2 + \cdots;$ • $R_{tot} = R_1 + R_2 + \ \ldots$	**Calculate** resistance, current and voltage in series and parallel circuits	Challenge the students to design a circuit using two or more switches placed in different positions which can govern the circuit alternately as found on staircases

YEAR S4	**TOPIC: Electricity**	Pre-knowledge: S3 science introduces isolators and conductors. S3 science already teaches the behaviour of current and voltage in circuits. The relationship between energy, power and time, and kWh ~~is~~ are already taught in S3 science.	
Subtopic	**Content**	**Learning objectives**	**Key contexts, phenomena and activities**
	▸ Parallel: • $I_{\text{tot}} = I_1 + I_2 + \cdots;$ • $U_{\text{tot}} = U_1 = U_2 = \cdots;$ • $\frac{1}{R_{\text{tot}}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$	**Construct** circuits from a schema and **measure** current and voltage	Parallel circuit as idea of home circuit
			Calculations with combinations of series and parallel can be considered with a motivated class
Electricity at home	Power: $P = U\,I$ Energy: $E = P\,t$	**Explain** that electric circuits enable the transfer of energy at a distance and its transformation into heat, light, mechanical energy, and other appropriate forms	Safety at home Find the circuit breaker box and electricity meter at home and find out • the maximum amount of current that can be drawn • the number of kWh used in a day or a week • Identify which appliance uses the most energy in a week
	Commercial units of energy	**Express** power as the rate of energy transformation	
	Electrical safety in the home	**Explain** which safety measures are used at home for electricity, as isolation, earth leakage switch, earthing, fuse, ...	This can be combined with biology (and chemistry and math) by measuring also the use of water and gas or oil and the production of waste to determine the ecological footprint in a project
	Electrical devices at home	**Identify** multiple energy conversions in real life devices and **discuss** reasons for changing technologies of electrical devices such as light bulbs	Build and explain circuits with sensors and bulbs or resistors
			Sensors such as LDR, NTC could be addressed and students may **design** simple circuits with sensors as LDR and NTC

YEAR S4	TOPIC: Magnetism	Pre-knowledge: The idea of magnetic field is introduced in S3		
Subtopic	**Content**	**Learning objectives**	**Key contexts, phenomena and activities**	
Magnetism	Magnetic field, electromagnets	**Draw** the magnetic field diagram of a solenoid or magnet and **describe** the similarities between them		Examples of uses of magnetism and the Motor effect: • Door bells and buzzers • Deflection of electron beams (with Helmholtz coils or a permanent magnet) • Auroras • Fire door release mechanism • Motors and generators • Loudspeakers • Metal detectors • Maglev train • Bicycle speedometer
	Motor effect (qualitative principles)	**Explain** qualitatively how an electric motor works		Build yourself a model electric motor and/or make a cartoon strip to simply explain how an electric motor works
	Electromagnetic induction (qualitative principles) Consider motors and generators as energy conversion devices	**Explain** that a varying magnetic field in a coil induces an electric current and that the phenomenon is used in generators (no Lorentz force or calculations)		Similarities and differences between various electricity generating methods: gas turbine, windmills, hydroelectric, solar …

YEAR S4	TOPIC: Mechanics	Pre-knowledge: S1 science introduces speed, acceleration and graphs, $s = v \cdot t$ is used, no calculations with a have been done. The idea that forces can change velocity is introduced in S3. Gravity is introduced in S1		
Subtopic	**Content**	**Learning objectives**	**Key contexts, phenomena and activities**	
Accelerated motion	$s,\ v,\ a$: Define these quantities and distinguish between the vector and scalar terms	**Calculate** movements with constant speed		Measure time and distance for several ways of travelling for calculating the speed in m/s and km/h
	Speed $v = \frac{\Delta s}{\Delta t}$;			Make position-time graphs with a computer
	Acceleration: $a = \frac{\Delta v}{\Delta t}$; $s = \frac{1}{2}\, a\, t^2$	**Calculate** movement with constant acceleration		Make velocity-time graphs with a computer including freefall acceleration or inclined plane
	Distinguish between instantaneous and average velocities or speed	**Construct** and **analyse** $s(t)$ and $v(t)$ graphs to get information and **make calculations** using gradients and key points on the graphs		Relate freefall acceleration to the force of gravity $F = m\, g$
Effects of forces	Forces can: • Change speed • Change direction of motion • Deform materials	**Explain** that forces can change velocity or are balanced so nothing changes **Distinguish** between the force (invisible) and the effect of a force (visible)		
	Force as a vector: • Summing forces in 1 dimension • Extension of the concept of a sum of forces (resultant) to 2 dimensions	**Draw** vectors and vector sums graphically only		Extension of scale diagrams may be interesting: the concept of components: the effect in each of two perpendicular directions

YEAR S4	TOPIC: Mechanics	Pre-knowledge: S1 science introduces speed, acceleration and graphs, $s = v \cdot t$ is used, no calculations with a have been done. The idea that forces can change velocity is introduced in S3. Gravity is introduced in S1	
Subtopic	**Content**	**Learning objectives**	**Key contexts, phenomena and activities**
	Examples of common forces: • Gravitational force (weight) $F_G = m\,g$ • Tension • Normal force • Friction force	**Explain** that weight is a force and depends on mass and gravitational field strength	Methods of measuring g
		Use the correct name for a given force in written and oral descriptions	Hooke's law: Students investigate how the extension of a spring depends on mass attached to it
		Calculate magnitudes of weight, mass and field strength	Calculations could be explored
		Describe situations that give rise to the normal force	Why does the weight of an object appear to change when placed into different fluids? (Archimedes)
Forces in action	Newton's 1st Law Newton's 2nd Law for a given mass	**Calculate** the sum of forces in 1 dimension and **determine** force and acceleration from Newton's 1st and 2nd Law.	Experiments with constant force on an air track, without and with friction
	Consider mass as a measure of how easy or hard it is for a given force to change the motion of an object	**Explain** how mass affects the acceleration of a body when a net force acts on it	Experiments involving freefall and air resistance (Newton's coin and feather tube)
		Use the second law to **calculate** velocity at given time during a uniform acceleration	Investigate how air (or water) resistance changes with the speed of the object moving through it. Investigate terminal velocity
	Newton's 3rd Law	**State** that in a system of interacting masses an action provokes an equal and opposite reaction and **recognise** that these forces act on different bodies	Design a package with as little material as possible in which you can drop an egg from a height of 10m without breaking

YEAR S4	TOPIC: Mechanics	Pre-knowledge: S1 already introduces characteristics of sound qualitatively. Students are familiar with square roots	
Subtopic	**Content**	**Learning objectives**	**Key contexts, phenomena and activities**
Oscillators as a source of waves	Characteristics of the oscillating source	**Define** and **apply** the concepts of frequency, period and amplitude	Examples such as a mass on a spring or the simple pendulum can be explored
	Amplitude, frequency and period $f = \frac{1}{T}$		
Characteristics of Waves	Waves should be approached as energy on the move from an oscillating source without the transfer of matter	**Describe** the characteristics of waves	Ripple tank, loudspeakers, tuning forks etc. illustrate the characteristics of waves in amplitude and wavelength. Practical examples such as ocean waves, pitch and loudness of sounds, brightness and colours of light etc. can be explored.
	Common characteristics of all waves: wavelength, frequency, period, velocity, amplitude: $v = \lambda f; \quad s = v\,t$	**Make calculations** with frequency, velocity and wavelength	
	Longitudinal and transverse waves	**Distinguish** between longitudinal and transverse waves and **list** examples	
Sound	Apply the characteristics described above to sound waves	**Explain** qualitatively how a musical instrument makes sound and what determines the characteristics of the sound	Students design an experiment to measure the velocity of sound
		State other examples of similar waves to sound such as sonar, ultrasound or shock waves	Explore the audible range of the human ear
			A room with and without curtains and furniture, design of a concert hall. The idea of echo
			Students investigate the frequency from a vibrating string as a function of the attached mass (or the tension F)
			Qualitatively relate ultrasound to sonar (echo location) and medical scanners

YEAR S4	TOPIC: Mechanics	Pre-knowledge: S1 already introduces characteristics of sound qualitatively. Students are familiar with square roots		
Subtopic	**Content**	**Learning objectives**	**Key contexts, phenomena and activities**	
Light and the electro-magnetic spectrum	Regions of the electromagnetic spectrum	**Identify** the different regions of the electromagnetic spectrum, **relate** them to frequency or wavelength		Discuss uses and applications of regions of the electromagnetic spectrum
				Discussion of lasers and photoelectricity could be engaged
				Historical methods for measuring the speed of light

- **Year S5**

YEAR S5	**TOPIC: Work and Energy (in Mechanics)**	Pre-knowledge: Newton's Laws are already covered in S4	
Subtopic	**Content**	**Learning objectives**	**Key contexts, phenomena and activities**
Work and energy	Mechanical work	**Use** the concept of work to **calculate** change in energy	Applications to situations like hydroelectricity
	The energy transformed when a body moves with or against a force $W = F\ s$ where distance moved, s, is parallel to the force, F		Energy transformations in situations like skiing, batteries in E-bikes and E-cars, fuel, etc.
	Gravitational potential energy E_P $\Delta E_\mathrm{p} = m\ g\ \Delta h$	**Calculate** kinetic and gravitational potential energy. **Calculate** transformations between them including the use of the work formula. **Calculate** how much time and distance is needed to stop a car. **Use** the idea of power from S4 with friction to do **calculations** about power and maximum velocity.	Factors affecting the efficiency of energy transformations
	Kinetic energy: $E_\mathrm{k} = \frac{1}{2}\ m\ v^2$		Context of driving safety
	Conservation of energy: $\sum E_\mathrm{before} = \sum E_\mathrm{after}$		How to reduce energy losses through resistive forces in cars, aeroplanes, ships, etc

YEAR S5	TOPIC: Matter and Heat	Pre-knowledge: S2 introduces the particle model of solids, liquids and gases. S4 chemistry also gives attention to particle model and micro-macro thinking. S2 gives a particle model for transitions of state. S3 gives attention to transitions between different forms of energy without calculations. The mole and Avogadro are introduced in S4 chemistry. S4 biology talks about cooling and sweating		
Subtopic	**Content**	**Learning objectives**	**Key contexts, phenomena and activities**	
Particles and the structure of matter	Random motion and forces between particles of matter	**Describe** the behaviour of molecules in different states of matter		Contexts for energy exchange due to change of state: cooling of aerosol cans when they are operated, refrigeration, practical heat pumps
	Temperature as a measure of average kinetic energy of particles. The Kelvin scale. The concept of absolute zero	**Determine** the equivalent temperature in Kelvin from Celsius and vice versa		
	Transitions between states	**Explain** why a change of state involves energy exchange		
	Energy required or released during a change of state			
	Boiling, melting and evaporation should be considered along with the reverse processes	**Give a reason** as to why temperature stays constant when a pure material changes state at its boiling or melting point		Examples can be used from weather phenomena
	Heat and mechanical work seen in the expansion and compression of gases	**Explain** why gases cool when they expand and heat when compressed (no calculations)		Heating of air when compressed (Demonstration: igniting cottonwood by quickly compressing air in a transparent tube)
Heat energy	Heat to change temperature: $Q = m\,c\,\Delta T$	**Calculate** in problems and experiments involving • specific heat capacity, c • specific latent heat, l • the law of conservation of energy • concept of efficiency		Measuring temperature in time by heating water and making diagrams
	Latent Heat to change state: $Q = m\,l$			Method of mixtures experiments and problems could be explored
				Experiments to compare the efficiencies of different methods of heating
				Discuss practical applications of the high specific heat capacity of water such as for central heating systems, water cooled engines, moderating maritime climate, coastal breezes, ocean heat conveying currents

YEAR S5	TOPIC: Conservation of Momentum	Pre-knowledge: Newton's Laws, Force as a vector. Velocity and acceleration (S4)		
Subtopic	**Content**	**Learning objectives**	**Key contexts, phenomena and activities**	
Momentum	Momentum: $p = m\,v$	**Describe** momentum as the quantity of motion of a body and **calculate** its momentum		Compare the momenta of various objects: low mass moving quickly like a bullet and a large mass moving slowly like a bowling ball
Application of Newton's 3rd Law to collisions and propulsion	Conservation of momentum	**Identify** the objects within a closed system to which conservation of momentum applies		Propulsion mechanisms such as reaction engines could be discussed where mass varies or the force at the end of a water canon/hosepipe
		Describe interactions between objects where two concepts are required to predict the outcomes: momentum and energy		Experiments with a simple air rocket could be explored or trolleys connected by a spring
				Corresponding situations could be researched: a) ion engines or light sails b) Projectile launchers like canons or rifles
				Consider elastic collisions (e.g. billiard balls) and inelastic collisions (e.g. kinetic energy converted into deformation energy in a car accident)
				Calculations can be made to conservation of linear momentum in these phenomena

YEAR S5	TOPIC: Atomic and Nuclear Physics	Pre-knowledge: How an atom is built; periodic system; isotopes (s4-chemistry). S5-chemistry introduces the orbital model, Pauli’s exclusion principle and nuclear structure and processes	
Subtopic	**Content**	**Learning objectives**	**Key contexts, phenomena and activities**
Fundamental Particles and Forces	Electrons, neutrons, protons	**Describe** the charge and mass and dimensions of these particles and how they contribute to the structure of the atom	A deeper discussion could be engaged with motivated students. CERN’s “Particle Adventure” website and others like it can be used to explore particle accelerators for probing matter, quarks, the structure of nuclear particles, the Standard Model, exchange model of forces and the Higgs Boson
	Fundamental forces that cause interactions between particles	**State** that there are only a few fundamental forces	
		Describe qualitatively their role in the structure of an atom	
		Apply the notation $^{A}_{Z}X$ to **describe** the structure of a nucleus	Discussion of how the numbers of neutrons and protons determine the stability of the nuclei they form
	Isotopes	**Distinguish** between different isotopes of an element and **relate** the difference to the respective numbers of neutrons	Neutron stars and other exotic examples of particles in nature could be researched
Radioactive decay	Activity A, half-life, nuclear radiation Decay with α, β and γ radiation	**Identify** the decay product when an atom decays with alpha or beta radiation (no electron capture, or beta+ decay). **Determine** the activity or quantity of a radioisotope remaining after a few half-lives or vice versa. Only whole numbers of half-lives: no calculations with logarithms or exponentials	Together with mathematics (probability rules) and also from an experiment with 100 dice or coins students gain insight about half-life and probability
	Reaction equations	**Construct** a balanced reaction equation for a decay	
		Explain the emission of gamma radiation as emission of electromagnetic energy from the nucleus	Experiment with beer froth

YEAR S5	TOPIC: Atomic and Nuclear Physics	Pre-knowledge: How an atom is built; periodic system; isotopes (s4-chemistry). S5-chemistry introduces the orbital model, Pauli's exclusion principle and nuclear structure and processes	
Subtopic	**Content**	**Learning objectives**	**Key contexts, phenomena and activities**
			The discovery of radioactivity.

YEAR S5	TOPIC: Atomic and Nuclear Physics	Pre-knowledge: How an atom is build (S4-chem); periodic system (S4-chem); isotopes (S4-chem). S5-chem introduces the orbital model, Pauli's exclusion principle and nuclear structure and processes	
Subtopic	**Content**	**Learning objectives**	**Key contexts, phenomena and activities**
Ionising radiation	Penetration of radiation, diagnostics, treatment in simple words, use of ionising radiation	**Apply** the concept of ionisation to **explain** the need for safety measures	Ionising radiation and safety
		Give reasons for the use of short living isotopes in diagnostics and treatment	Students could research examples of medical imaging and/or treatment or industrial applications that uses ionising radiation. Presentation to the other students
		Discuss the risk of radiation qualitatively in terms of activity, energy of radiation and time of exposure	Background radiation and situations presenting different levels of risk such as increased exposure to radiation due to radon gas, or cosmic rays (during a plane flight or time in space), or periods of increased solar activity
Nuclear energy from fission and fusion	Mass as a form of energy	**State** that when nuclear reactions release energy, the mass of the products is less than that of the reactants as described by $E = m\,c^2$	Student could research the advantages and disadvantages of different energy sources with respect to need, time for construction, resources, environment and health risks. This can be done together with chemistry and biology in the context of energy transition. This could end in a class debate.
	Examples of fission reactions		

YEAR S5	TOPIC: Atomic and Nuclear Physics		Pre-knowledge: How an atom is build (S4-chem); periodic system (S4-chem); isotopes (S4-chem). S5-chem introduces the orbital model, Pauli's exclusion principle and nuclear structure and processes	
Subtopic	**Content**	**Learning objectives**	**Key contexts, phenomena and activities**	
	How this results in a chain reaction Examples of fusion reactions	**Identify** fission and fusion from reaction equations and **construct** balanced reaction equations.		Fusion of hydrogen in stars, ITER as a possible nuclear (fusion) powerplant.
	Nuclear power	**Explain** how a fission reaction can lead to chain reaction. **Describe** how this leads to an uncontrolled explosion and **explain** how it can be controlled in a nuclear reactor.		Advantages and disadvantages of fusion in relation to fission (for example nuclear waste, fusion temperature).

5. Assessment

For each level there are attainment descriptors which are listed in the following table and explained by the competences. They give an idea of the level that students have to reach. They also give an idea of the kind of assessments that can be done. Pupils should be assessed in a broad variety of ways throughout the year, to give a wide-ranging picture of each pupil's attainments, strengths, and areas for further work.

Assessment is summative when it is used to evaluate student learning at the end of the instructional process or of a period of learning. The purpose is to summarise the students' achievements and to determine whether, and to what degree, the students have demonstrated understanding of that learning. Summative assessment evaluates the student's learning by long written tests in S4 or later in S5. The S5 physics exam, must always be completely harmonised between the language sections.

Assessment is formative when either formal or informal procedures are used to gather evidence of learning during the learning process, and are used to adapt teaching to meet student needs. The process permits teachers and students to collect information about student progress and to suggest adjustments to the teacher's approach to instruction and the student's approach to learning.

Formative assessment takes place in almost every lesson of the school year and should include the following:

- Lab reports
- Presentations
- Tests of subject content
- Tests of practical skills
- Self and peer evaluation

The competences are expressed in the table as a set of verbs that give an idea of what kind of assessment can be used to assess that goal. In the table with learning objectives these verbs are used and put bold, so there is a direct link between the competences and the learning objectives.

Assessing content knowledge can be done by written questions where the student has to respond on. Partly that can be done by multiple choice but competences as constructing explanations and engaging in argument as well as key competences as communication and mathematical competence need open questions or other ways of assessing.
An assignment where students have to use their factual knowledge to make an article or poster about a (broader) subject can be used to also judge the ability to critically analyse data and use concepts in unfamiliar situations and communicate logically and concisely about the subject.
Students have to be able to do an (experimental) inquiry. An (open) inquiry should be part of the assessments. Assessing designing and inquiry can be combined with other subjects.
Digital competence can be assessed by working with spreadsheets, gathering information from internet, measuring data with measuring programs and hardware, modelling theory on the computer and comparing the outcomes of a model with measured data. Do combine this with other assessments where this competence is needed.

For all assessment, the marking scale of the European schools shall be used, as described in "*Marking system of the European schools: Guidelines for use*" (Ref.: 2017-05-D-29-en-7).

5.1. Attainment Descriptors

	A (9,0 - 10 Excellent)	**B** (8,0 - 8,9 Very good)	**C** (7,0 - 7,9 Good)	**D** (6,0 - 6,9 Satisfactory)	**E** (5,0 - 5,9 Sufficient)	**F** (3,0 - 4,9 Weak/Failed)	**FX** (0 - 2,9 Very weak/Failed)
Knowledge	Displays comprehensive knowledge of facts	Displays a very broad knowledge of facts	Displays a broad knowledge of facts	Displays a reasonable knowledge of facts and definitions	Recalls main names, facts and definitions.	Displays little recall of factual information	Displays very little recall of factual information.
Comprehension	and a thorough command and use of concepts and principles in science.	and a good command and use of concepts and principles in science.	and good understanding of main concepts and principles in science.	and understanding of basic concepts and principles in science.	Understands only basic concepts and principles in science	and a limited understanding of concepts and principles in science.	Shows very little understanding of scientific principles and concepts.
Application	Makes connections between different parts of the syllabus and applies concepts to a wide variety of unfamiliar situations and makes appropriate predictions.	Makes some connections between different parts of the syllabus and applies concepts and principles to unfamiliar situations.	Is capable of using knowledge in an unfamiliar situation.	Is capable of using knowledge in a familiar situation.	and can use basic knowledge in a familiar situation.	/	/
Analysis	Is capable of detailed and critical analysis and explanations of complex data.	Analyses and explains complex data well.	Produces good analysis and explanations of simple data.	Produces basic analysis and explanations of simple data.	Given a structure can analyse and explain simple data.	Can use data only with significant guidance.	Fails to use data adequately.
Experimental work	Formulates hypotheses, plans and carries out investigations using a wide range of techniques while being aware of ethical issues.	Plans and carries out experiments using appropriate techniques, being aware of safety issues.	Follows a written procedure safely and makes and records observations, presenting them using different techniques.	Follows a written procedure safely and records observations.	Follows a written procedure safely and makes basic observations.	Has difficulty following instructions without supervision.	Is not able to safely follow a written procedure.

	A (9,0 - 10 Excellent)	**B** (8,0 - 8,9 Very good)	**C** (7,0 - 7,9 Good)	**D** (6,0 - 6,9 Satisfactory)	**E** (5,0 - 5,9 Sufficient)	**F** (3,0 - 4,9 Weak/Failed)	**FX** (0 - 2,9 Very weak/Failed)
Digital and Information Competences*	Can consistently independently find and assess the reliability of, information on scientific subjects, on- and offline. Can independently use appropriate software for science tasks.	Can usually independently find and assess the reliability of, information on scientific subjects, on- and offline. Can use appropriate software for science tasks with some assistance.	Can often independently find and assess the reliability of, information on scientific subjects, on- and offline. Can use appropriate software for science tasks with assistance.	With aid, can find and assess the reliability of, information on scientific subjects, on- and offline. Can use appropriate software for science tasks given structured assistance.	Can retrieve information on scientific subjects when directed to reliable sources, on- and offline. Can follow structured instructions to use appropriate software for science tasks.	Generally unable to find, or to assess the reliability of, information on scientific subjects, on- and offline. Has great difficulties using appropriate software for science tasks even with assistance.	Unable to find, or to assess the reliability of, information on scientific subjects, on- or offline. Unable to use appropriate software for science tasks even with assistance.
Communication (oral and written)	Communicates logically and concisely using scientific vocabulary correctly. Demonstrates excellent presentation skills.	Communicates clearly using scientific vocabulary correctly. Demonstrates very good presentation skills.	Communicates clearly most of the time using scientific vocabulary correctly. Demonstrates good presentation skills.	Uses basic scientific vocabulary, and descriptions show some structure. Demonstrates satisfactory presentation skills.	Uses basic scientific vocabulary, but descriptions may lack structure or clarity. Demonstrates satisfactory presentation skills.	Generally produces descriptions that are insufficient or incomplete with a poor use of scientific vocabulary. Lacks acceptable presentation skills.	Has very poor Communication and presentation skills.
Teamwork	Shows initiative – a team leader.	Works constructively in a team.	Works well in a team.	Works satisfactorily in a team.	and participates in team work.	Needs assistance when working in a team.	Does not work in a team.

*) This competence is part of the European Digital Competence Framework (https://ec.europa.eu/jrc/en/digcomp)

Annex

Physics in S4 - S5 is a discipline where students attempt to discover and apply general laws which govern force and motion, matter and energy, and space and time. Observing phenomena, experimenting, finding models to explain and predicting the behaviour of matter are important tasks in physics. Students learn by doing, by analysing and by communicating about physics. As they are getting older, physics becomes more abstract and more mathematical.

Safety shall be given priority. Teachers must start the S4 - S5 physics course with an introduction to safety in the lab as well as each experiment by focussing on the specific safety issues for the activity. Furthermore, safety must be part of the evaluation of the competence ‘experimental work’.

The syllabus does not include teaching hours, because teaching time does not only depend on the content but also on the competency being taught.

The table below gives approximate times and are for guidance only.

Topic	Periods in S4	Periods in S5	Total periods
Electricity / magnetism (4.1, 4.2)	20	0	20
Mechanics (4.3, 5.1, 5.3)	18	22	40
Waves (4.4)	12	0	12
Matter and Heat (5.2)	0	12	12
Atomic and Nuclear (5.4)	0	16	16
Total	**50**	**50**	**100**