Chapter I

Country requirements, traditions and issues in use of ICT for Science teaching and learning

1.1. Science Curriculum Requirements for secondary and primary level of education

The field of Science education comprises across Europe curriculum contents related to the following school subjects: Mathematics, Physics, Chemistry, Biology and Geology. In a limited number of cases, such as the case of Spain, Science area inclused transversal, integrated school subjects like science, technology and society, a subject aimed to study the social aspect ot the science and their impact in the past, in the present, and in the future in our society. All these subjects are included in lower and upper secondary curriculum with different number of teaching hours at different levels. Science curriculum offer vary in different European educational systems in terms of:

- contents structure and degree of contents integration
- types of competences targeted and trained
- recommended teaching methodologies
- types of learning experiences to be organized

One of the main objectives of the European project Virtual Community Collaborating Space for Science Education was identifying the suitable and up to date tools that offer teachers of Sciences in different European countries the possibility to effectively meet national curriculum requirements while proposing dynamic and relevant learning situations based on scientific reality experimentation through electronic means and into an virtual learning space. Consequently a thorough analysis of the Science curriculum requirements was made, in terms of Science teaching aims and objectives, values and attitudes, contents and typical learning situation. Added to this, we detailed the trends in European countries in Science teaching and learning in terms of:

- new methodologies that are advised
- new teaching behaviours

- new roles for the students
- new ways of evaluation
- new technologies and materials
- other new curricular recommendations and trends

The above mentioned project involved educational specialists form five European countries: Spain, Poland, Greece, Finland and Romania. The specific data we offer in the following table particularly reflect the Science teaching realities in these countries. However, given the balanced distribution of the involved countries across Europe and different European communities (former communist countries, Northern and Southern European countries Western European countries) we trust that the data presented here can be regarded as relevant for the European Science teaching and learning in general.

SPAIN				
School discipline	**General objectives of the school discipline**		**Main topics for each discipline**	
	Lower secondary	Upper secondary	Lower secondary	Upper secondary
Mathematics	- Add to habitual different language and simple mathematical expressions (digital, graphic, geometric, logic, probability). - Using a precise and rigorous mathematical expressions simple language (numeric, graphic, geometric logic, probability). - Using logic to organize, link and test data of everyday life in solving problems. - Quantitatively assess and verify actual measures surrounding the purpose of better understanding the reality. - Employing various means, numbers and fundamental units of length, capacity, mass, time, size and breadth of angles in the collection of information and data for use in problem solving.	- Incorporate the language and common forms of argumentation of the students the various forms of mathematical expression (numerical, algebraic, geometric features, statistics, probability ,...), in order to be more precise in the communication and give some rigor. - Quantify some aspects of reality to be able to interpret better, using different kinds of numbers (integers, fractional, decimal ,...) by performing calculations appropriate to each situation. - Power use in certain situations, the forms of logical thinking to: establish relationships, analyze properties and deduce laws or formulas. - Understand and comprehend the algorithms and procedures on the algebraic language for the resolution of problems in real life. - Using concepts and terminology from business to learn interpretation of mathematics and produce reports that refer to: Proportions, percentages, numbers and rates in general situations that have to do with domestic financial situations.	- Using strategies and techniques in problem solving. - Description of procedures for solving problems. - Using technology tools to facilitate the kind of numerical calculations, algebra or statistics. - Numbers natural. - Severability. - Measure - Rational Numbers. - Negative Numbers. - Magnitudes directly and inversely proportional - Whole Numbers. - Calculation of mind. - Algebraic language. - Reading, writing and interpretation of formulas and algebraic expressions. - Identities and equations. - Using equations to solve problems. - Geometry Plana. - Angles. - Triangles	- Severability, whole numbers and powers - The real numbers: Fractions. - First-degree equations with one unknown. - Systems of two equations of first grade. - Second degree equations and inequalities. - Reasons trigonometric - Measurement of angles. - Polygons, circle, circle and mosaics. - Thales' theorem and likeness. -Theorem of Pythagoras. - Regular Polyhedra, prisms and pyramids. - Bodies of revolution: cones, cylinders, spheres - Features & Charts. - Statistical studies: Samples. Statistical parameters - Probability. Laplace rule - For questions, Hyperbole - Elementary Functions - Exponential Functions - Logarithmic function - Trigonometric functions. - Statistics bidimensional - Probability compound

	- Employing various means and procedures (algorithms, calculator, computer, etc.). In solving problems and describe them orally. - Contrast the procedures followed in resolving problems in order to determine which works best in each situation. - Apply simple methods of data collection and management of these tables to represent them in numerical and graphical. - Draw conclusions simple, as accurate as possible, in numerical and graphical representations. - Understand reality from different points of view, using various methods to estimate and measure. - Recognizing the different shapes of real plane figures (polygons circle and circle). - Analyze and compare the different properties of geometric shapes, appreciating its beauty. - Recognize graphs, statistics, calculations, etc.	- Valuing the excellent virtues that provides the algebraic language to describe various situations and to resolve certain problems. Revise and strengthen working methods and ways to facilitate the resolution of basic algebraic problems. - Recognize similar figures, including triangles, and the rate of similarity as a relationship between them. Relate through scales and saberlas use to interpret drawings. - To analyze the properties of the movements in the plane and put on the possibilities on teselación and training of mosaics connection of mathematics with art, the beauty of the compositions that can be generated. - Identifying geometric shapes in space. Develop the perception of their property and use laws and formulas to determine areas and volumes. In particular the study of the area. - Knowing the general nature of their functions and graphics. In particular, the linear proportionality, quadratic and exponential, its graphic and analytic expressions so as to make assessments of the situations that are depicted. - Using basic knowledge about samples and surveys, to interpret and develop information on various situations or phenomena. Representing this	- Similarity - Geometry in space. - Interpretation and reading charts - Graphical representations of a simple algebraic expression. - Probability and Statistics: Collection of information. Processing and interpretation of tables. Mean, Median, Fashion spreadsheet to organize data.	

	In the different media, on topics of interest to form its own criteria for critical analysis. - Appreciate the importance of mathematics in problem solving and real-life situations and persevere in the search for solutions. - To know and assess their math skills to use them safely and firmly when the situation demands and appreciate the different aspects that may occur (creative, manipulatives, aesthetic, and so on.) Recognizing the mistakes and the causes that have occurred.	information in numerical and graphical form. - Knowing basic aspects of the behavior of random and on probabilities of various phenomena. Awareness of the regularities and laws governing the phenomena of chance. - Identify possible mathematical concepts (percentages, statistical, graphs, scales ,...) in newspaper reports and advertising, a critical way of analyzing the role and value their contribution to a better understanding of the messages. - Improving the methods and attitudes in resolving problems: the systematic exploration of alternatives, the flexibility to change their point of view, perseverance in finding solutions, the use of particularism and the generalization, systematization. - Discover and appreciate the skills of the students to reinforce the confidence with which confront the mathematical tasks, both utilitarian as the kind of creative.		
Values: independent, creative, open, objective thinking, curiosity and imagination in problem solving, tenacity, perseverance and concentration capacity, habit of using the mathematical concepts and methods in solving daily life problems, motivation for study of mathematics as a relevant field for social and professional life				

Physics and Chemistry	- Teaching students the knowledge and application of scientific method. - Understand and express scientific messages using the oral and written language properly, and to interpret diagrams, graphs, tables, simple mathematical expressions and other models of representation. - Interpreting the main natural phenomena scientifically, as well as its potential technological applications, using the laws and concepts of Natural Science. - Participate in a responsible manner in the planning and conduct of scientific activities. - Use of independent sources of information, including new information technologies and communication, in order to evaluate i content and attitudes personal criticism on scientific and technological matters. - Acquire knowledge about the functioning of the	- To understand the concepts, laws, theories and models most important to enable them to have a comprehensive and scientific literacy studies to develop more specific. - Apply the concepts, laws, theories and models learned to everyday situations. - Analyze, compare opposing theories and assumptions in order to develop critical thinking and value their contributions to the development of these sciences. - Use research skills, both documentary and experimental, with some autonomy, recognizing the nature of science as an evolving and dynamic process. - Resolve alleged physical and chemical, both theoretical and practical. - Recognize the cultural contributions that have Physics and Chemistry in the formation of the individual, as well as the implications that are both in the development of technology in their applications for the benefit of the Company. - Understand the scientific terminology to be able to use it on a regular basis to express themselves in science, as well as to explain the terminology through language daily	- Earth in the Universe - Universe and Solar System. - Matter in the Universe. - Middle Earth: - Atmosphere - Hydrosphere - Geosphere - The life and its diversity - The Earth as a planet inhabited - The phenomenon of life. - Diversity of living things. Biodiversity. - Descriptive study of the major groups of living things. -The value of biodiversity. Current problems. - Life along the Earth History. Fossils. - Matter and Energy - The energy systems in materials. - Transfer of Power - Heat and Temperature. - Light and Sound - Transformations geological due to internal energy of the Earth - Transfer of Power in the interior of the Earth. - Magmatic and metamorphic rocks - Internal Geodynamics.	- Unity and Diversity of structure of matter - The corpuscular nature of matter. Kinetic model of gases - The atomic-molecular theory of matter. Pure substances and mixtures. Simple and compound substances. Dissolutions. - Internal structure of the substances - Electrical properties of matter. Electrical phenomena. Electric current. - Structure of the atom. Chemical elements. Isotopes - Chemical changes and their implications. - Chemical reactions and their importance. - Launching the study of carbon compounds. - Links Ionica, and covalent metal - Hydrocarbons, acids and alcohols. - Macromolecules. - Role of chemistry in the understanding of the origin and development of life. - Chemical reactions. - Acidic and basic solutions. - The forces and movements. - Character vector of forces. - Principles of dynamics. - Universal Gravitation. - System geocentric. - Weight of the bodies. - Static fluid. - Pressure. - Buoyancy - Barometer. - Energy, work and heat. - Machines, pulleys and inclined plane

	human body to develop and strengthen habits and physical health care and critical attitude to drug abuse. - Apply knowledge acquired in the Science of Nature to enjoy the natural environment, valuing and participating in their conservation and improvement. - Recognizing and valuing the contributions of science to the conditions of existence of human beings and appreciate the importance of scientific training. - Understand scientific knowledge as being integrated, which compartment in different disciplines to deepen the different aspects of reality.		- Life in action. Vital functions - Seres inert and lifeless. The phenomenon of life. - The relationship: Interaction of living things with their internal and external environment. - The playback. - The natural environment - The environment and its components. - Major types of ecosystems and their dynamics. - The natural environment in Spain	- Waves: light and sound. - The contribution of science to a sustainable future
Values: Care for the environment, interest for rational argumentation, development of tolerance towards the oppinions of others, curiosity for the new openings in the filed of science, interest for the technological, scientific and natural environment information, curiosity for the simulation and modeling of the natural phenomenon through experimentation, interest for the way ideas and theories develop in nature sciences. Respect for truth and thorough observation, personal initiative, Interest and curiosity, disposition for the optimization of own performance, skepticism for making generalizations that are not based on observations that are verifiable/ repeatable, openness for the opinions of others and disposition to modify own perspectives in the light of new facts.				

GREECE				
School discipline	**General objectives of the school discipline**		**Main topics for each discipline**	
	Lower secondary	Upper secondary	Lower secondary	Upper secondary
Mathematics **General objectives:** Analyzing and studying Mathematics in terms of: a) Mathematical knowledge, b) Language, c) Practicality and usefulness, d) Mathematical structure, e) Methodology, f) its Dynamic dimension and g) Students' attitudes towards Maths	**General objectives:** • Completion of students' personality and their successful integration in the society through their involvement in problem solving situations encouraging: formal, analytic, logic, critical and abstract thought as well as the formation of generalizations and of precise, clear and severe expressions. • Encouragement of observation skills, attention, concentration, persistence, initiative, creative imagination, free and critical thinking, order harmony and beauty. • Pointing out the usefulness of mathematics in every-day life, in the work space, in science, in technology as	Students have to be able to: • form solution plans and develop appropriate solution strategies to face unfamiliar situations • be familiarized with mathematical proof • develop critical mathematical thinking • acquire a solid background of both; mathematical knowledge and skills to successfully continue their studies in Tertiary education* as well as to face real life situations, in modern reality • recognize the applications of Mathematics in other scientific disciplines • use calculators and computers in solving problems • present orally/ written and using computers their mathematical ideas using the language and the features of mathematics	**Algebra** • Natural numbers. • Ordering, approximation, operations, exponents. • Euclidean division, • Divisibility • Fractions and operations within fractions, • Decimal numbers, equations and problems • Proportional entities- reversible proportional entities • Positive and negative numbers: operations, exponents • Equations (αx+β=0, $y = ax^2 + \beta x + \gamma$, fractional equations) • Inequities, Real numbers, Pythagorean theorem, square root of a positive number, irrational numbers , Functions: y = αx, y = αx+β , yχ=α, • Descriptive statistics, trigonometrical numbers of a **οξείας γωνίας** – Vectors, Algebraic expressions, systems of linear equations, functions, probability,	Calculus. Equations and systems of linear equations Ordering in R. Roots of real numbers Line equation Basic trigonometric numbers Functions: domain, truth set, monotony, extrema Study of simple functions such as: $y = \alpha x + \beta$, $y = \alpha x^2$, $y = \frac{\alpha}{x}$, $y = \alpha x^3$, $y = \lvert x \rvert$, $y = \sqrt{x}$, $y = ax^2 + \beta x + \gamma$. • Roots of $a\chi^2 + \beta\chi + \gamma = 0$. • Rate of variation of $y = \alpha x + \beta$, $y = \alpha x^2$ • Trigonometry: Basic trigonometric functions: sinx, cosx, tangx, Basic trigonometric equations, Trigonometric numbers of added arcs and translation of this sum in product of trigonometric numbers, the sinus/co-sinus laws. • Polynomial equations

	well as in the Economy and in Social Sciences. **Specific objectives** Acquire: • Basic mathematical knowledge and skills • Basic mathematical language • Basic understanding of the basic characteristics of the structure of mathematics • Familiarization with deductive reasoning and mathematical proof • Basic competencies in problem solving especially in real life situations • A sense of the usefulness of mathematics in Sciences, in Humanities, in Social and also in Economic Sciences. • A sense of the dynamic character of mathematics as a necessary tool in all human activities • A positive attitude about mathematics	• develop exporation/ investigation and problem solving capacities * for specialised highschools	trigonometrical numbers of an angle, relationships among the trigonometrical numbers of an angle, sinus/co-sinus laws. • **Geometry** • Basic geometrical concepts; Plane, point, segment, line, ray, half plane, plane figures, shapes with straight segments, equal shapes, measurement of length, angles, perpendicular and parallel lines, circle, symmetry, triangles, parallelograms, trapezium, parallel lines intersected by a incidental line. • Areas of plane surfaces. • Metrics in circle, • Regular polygons, • Geometrical solids, • Volumes equity, • Similarity	• Progressions, sequences as specific functions and limits • Exponential – logarithmic functions: problem solving • Basics of numbers theory • Vectors- straight line • Equations of conical surfaces • Complex numbers • Percentages, approximation in calculating προσεγγιστικοί υπολογισμοί μεγεθών • Elements of Analytic geometry • Elements of Algebra Boole • Probability – Statistics • Derivative • Arrays, linear systems • Vectors in space • Functions-Limits and Continuity • Integration **Geometry** • Introductory concepts: Point, line, plane, basic geometrical shapes such as segment, angle, triangle, circle • Geometrical proof • Triangles and equity • Line in plane • Quadrilaterals: Rectangles, Parallelograms, trapezium, inscribed and described quadrilaterals • Geometrical constructions • Proportion and similarity • Triangle and circle: metric relationships

				• Areas • Measuring the area and the length of a circle • Lines and Planes in space • Solids
Values: personal development, social integration, develop structured and critical thinking abilities, analytic and synthetically thinking, abstraction and generalisation, expression of their thoughts in a neat, clear, simple and accurate way, observation, self-concentration and persistence, stimulate their initiative, creative imagination and freethinking and develop their sense of order, harmony and beauty, solving everyday life problems, making connections to other scientific disciplines, especially Technology, Economics and Social Studies. Recognize the interconnection of mathematical concepts with Fundamental Cross-thematic concepts such as: Change, Interaction, System, Communication, Individual-Group/ Element-Set, Similarity-Difference, Space.Time, Symmetry, Culture, Organization, Classification, Probability, Analysis-synthesis, Equality, Equivalence, Art.				
Physics The teacher must use modern ways of psychology and educational research to form the appropriate learning activities. The main goal is to bring modern ideas and topics of Physics in the front line of student's knowledge, adopted in the intellectual level and interesting of students	The main goals for the students are: • to acquire knowledge for the basic theories, laws and principles related with the Physics, in order to be able to describe and understood in simple and unified way the physical phenomena. • to recognize the prime role of the Physics Science in the development of the technology and the environment protection. • to improve the scientific way of thinking	The main goals for the students are: • to acquire knowledge for the theories, laws and principles related with the Physics, in order to be able to describe and understood in simple and unified way the physical phenomena. • to improve the scientific way of thinking and scientific methodology (observation, data collection, data analysis, conclusions, experiments etc). • to improve intellectual abilities for problem solving, critical thinking, creative imagination and communication skills. • to learn following the safety rules in the laboratories and every day life. • to recognize the prime role of the Physics Science in the development of the technology and the environment protection • to the recognize of the unity and the continuity of the scientific thinking in the natural sciences. **Values:** • Recognize the interconnection of physical concepts and phenomena with Fundamental Cross-thematic concepts such as:	• Mechanics, • Kinetics, • Dynamics, • Force, • Pressure • Power and Energy • Heat • Electricity, Electric Circuits • Oscillations • Waves • Acoustics • Optics • Nucleus and • Nuclear phenomena.	• Dynamics, • Kinetics, • Momentum and Energy Conservation, • Electromagnetism, • Oscillations, • Waves • Atoms and Nucleus • Optics **Curriculum (advanced)** • Thermodynamics • Electromagnetism • Oscillations • Waves • Solid Body Mechanics

without loss of rigorous scientific value. The teacher supports the student to: explain the natural phenomena, build and use appropriate models, trying to describe, interpret and predict natural phenomena and procedures. The use of new tools (such as educational software, www etc) today plays an essential role in the teaching procedure.	and scientific methodology (observation, experiments, data collection, data analysis, conclusions etc).	Space–Time System, Interaction, Culture, Communication , Change. • Recognize motion as one of the main properties of matter; • Relate change of motion to the concept of application of force; • Relate changes occurring in nature to energy transfer or transformation, in order to be able to describe in a consistent way chemical and biological phenomena; • Understand that energy manifests itself in different forms and that it is conserved. • Understand the relationship of different forms of energy. • Understand the harmful effects of nuclear energy on living organisms. • Care for the environment, interest for rational argumentation, • Development of tolerance towards the opinions of others, • Curiosity for the new openings in the filed of science, • Interest for the technological, scientific and natural environment information, • Curiosity for the simulation and modeling of the natural phenomenon through experimentation, • Interest for the way ideas and theories develop in nature sciences		• Quantum Mechanics • Relativity Theory.
Chemistry **General Objects** The teacher must use modern ways of psychology and educational research to form the appropriate learning activities.	The main goals for the students are: • to acquire knowledge for the basic theories, laws and principles related with the Chemistry, in order to be able to describe and understood in simple and unified way the chemical phenomena. • to recognize the prime	The main goals for the students are: • to acquire knowledge for the theories, laws and principles related with the Chemistry, in order to be able to describe and understood in simple and unified way the chemical phenomena. • to improve the scientific way of thinking and scientific methodology (observation, data collection, data analysis, conclusions, experiments etc). • to improve intellectual abilities for problem solving, critical thinking, creative imagination and communication skills. • to learn following the safety rules in the laboratories and every day life. • to recognizes the prime role of the Chemistry Science in the	• Introduction-What is Chemistry, Material states, Natural properties • From the water to the atom, Macrocosm, Microcosm • Atmospheric air, Oxygen Carbon Dioxide, Atmospheric pollution • Ground and Substratum, Ground pollution • Acid, Alkaline, Salt,	• Periodic Table o Elements, • Acid, Alkaline, Salt, • Nuclear Chemistry, • Radiochemistry, • Organic Chemistry I • Thermochemistry, • Chemistry kinetics, • Chemical Equilibrium, • Oxidation and Reduction, • Quantum Chemistry,

The main goal is to bring modern ideas and topics of Chemistry in the front line of student's knowledge, adopted ir the intellectual level and interesting of students, without loss of rigorous scientific value. The teacher supports the student to : explain the chemical phenomena, build and use appropriate models, trying to describe, interpret and predict chemical phenomena and procedures. The use of new tools (such as educational software, www etc) today plays an essential role in the teaching procedure.	role of the Chemistry Science in the development of the technology and the environment protection. • to improve the scientific way of thinking and scientific methodology (observation, experiments, data collection, data analysis, conclusions etc).	development of the technology and the environment protection • to recognize of the unity and the continuity of the scientific thinking in the natural sciences. **Values:** • Realize that knowledge of chemistry and its applications constitute cultural goods; • Realize that the irrational application of chemical knowledge can be harmful to human life and the environment; • Explore the physical properties of materials. • Relate chemical phenomena in their environment to entities and concepts of the microcosm; suggest measures to protect the environment • Realize the biological, environmental and technological importance of some chemical phenomena. • Recognize the properties of elements that are essential to technological development and the improvement of life quality. • Recognize the inter-connection of Chemistry concepts and phenomena with Fundamental Cross-thematic concepts such as: Change, Culture, System, Communication, • Similarity-Difference, Unit–Set, Dimension, Interaction, System, • Respect for inductive and deductive reasoning abilities, demand a relatively higher degree of abstraction as compared to the experimentation and building of physical models.	Applications • Periodic Table of Elements, Alkaline, Halogen, Silicon • Organic Chemistry, Carbohydrate, Petroleum • Living beings and Carbor combinations	• Acids , Alkalines and Ionic Equilibrium, • Organic Chemistry II.

FINLAND		
Physics and Chemistry Objectives of grades 5-6; primary school	General objectives of the school discipline	Main topics for the discipline
The starting point for instruction in physics and chemistry are the pupils' prior knowledge, skills and experiences, as well as their observations and investigations of natural phenomena, objects, and materials. From these, progress is made towards the basic concepts and principles of physics and chemistry. The instruction must stimulate the pupils to study science, help them consider the importance of a good and safe environment, and teach them to take care of their environment and act responsibly in it. Health education, in which the pupils' activities are examined from the perspective of safety and health, is integrated into the instruction.	The pupils will learn to • work and move about safely, protecting themselves and their environment and following the directions given • make observations and measurements, to look for information on the subject of study, and to weigh the reliability of the information • make conclusions about their observations and measurements and recognize the causal relationships associated with the properties of natural phenomena and objects • carry out simple scientific experiments clarifying the properties of phenomena, organisms, substances, and objects, as well as the correlations among them • use scientific knowledge in describing, comparing, and classifying concepts from the field of physics and chemistry • understand the dangers of drug abuse.	**Energy and electricity** • producing heat, light and motion with the aid of electricity; safety with electricity • various ways of producing electricity and heat; energy resources **Scales and structures** • the earth's gravity and friction, and motion and equilibrium phenomena due to forces • moving about safely and preventing accidents -motion of the earth and moon, and the resultant phenomena; structure of the solar system; the night sky **Substances around us** • composition of air; the atmosphere • properties of water and its importance as a solvent; investigation of natural waters; water purification • classification of substances from the soil; methods of separation • origin, utilization, and recycling of products and materials belonging to the living environment; safe usage of those products and materials • active substances in intoxicants and the harmful effects of those substances
Values (general for the basic education): human rights, equality, democracy, natural diversity, preservation of environmental viability, and the endorsement of multiculturalism, responsibility, a sense of community, and respect for the rights and freedoms of the individual; instruction in the different subjects is nondenominational and politically neutral.		

	Physics Objectives of grades 7-9; lower secondary school	General objectives of the school discipline	Main topics for the discipline
	The core task is to broaden the pupils' knowledge of physics and their conception of the nature of physics, and to strengthen skills in the experimental acquisition of information. The starting points for physics instruction are the pupils' prior knowledge, skills, and experiences, and their observations and investigations of objects, substances, and phenomena in the nature. From these, the instruction progresses towards the laws and fundamental principles of physics. The purpose of the experimental orientation is to help the pupils both to perceive the nature of science and to learn new scientific concepts, principles, and models; to develop skills in experimental work and cooperation; and to stimulate the pupils to study physics. The instruction guides the pupil in thinking in a manner characteristic of science, in acquiring and using knowledge, and in evaluating the	• learn to work and investigate natural phenomena safely, together with others • learn scientific skills, such as the formulation of questions and the perception of problems • learn to make, compare, and classify observations, measurements, and conclusions; to present and test a hypothesis; and to process, present and interpret results, at the same time putting information and communication technology to good use • learn to plan and carry out a scientific investigation in which variables affecting natural phenomena are held constant and varied and correlations among the variables are found out • learn to formulate simple models, to use them in explaining phenomena, to make generalizations, and to evaluate the reliability of the research process and results • learn to use appropriate concepts, quantities, and units in describing physical phenomena and technological questions • learn to evaluate the reliability of the information they have obtained from different sources • learn to use various graphs and algebraic models in explaining natural phenomena, making predictions, and solving problems	**Motion and force** • interactions and the corresponding forces; motion and equilibrium phenomena that arise from those interactions; occurrence of those phenomena in the nature • motion and models of uniform and uniformly accelerating motion • work done by a force; mechanical energy and power **Vibrations and wave motion** • various basic phenomena of vibrations and wave motion; production, detection, observation, reflection, and refraction of wave motion; related properties, quantities, and laws • importance and applications of sound and light • functioning principles of optical instruments **Heat** • phenomena associated with the heating and cooling of objects and substances; description of those phenomena with appropriate concepts and laws; importance and applications of thermal phenomena • conservation and degradation of energy; heat as a form of energy **Electricity** • electric and magnetic forces between objects • direct-current circuits; basic phenomena of electric circuits; safe application of those phenomena in everyday life and technology

	reliability and importance of knowledge in different life situations. The instruction gives the pupil the ability to discuss and write about questions and phenomena within the realm of physics and technology, using appropriate concepts. The instruction also helps the pupil understand the importance of physics and technology in everyday life, the living environment, and society. The study of physics supports the pupil in developing his or her personality, and in forming a modern world view. It also provides capabilities for making everyday choices, especially in matters related to environmental protection and the use of energy resources.	• learn about natural phenomena and processes and the transformations of energy that take place in them, know about various natural structures and the interactions of their components, and understand causal relationships between phenomena.	• electromagnetic induction and its use in energy transmission; use of electricity at home **Natural structures** • natural structures and proportions • interactions that keep structural components together; binding and release of energy in processes occurring between components • radioactive decay; fission and fusion; ionizing radiation and its effect on animate nature; protection from radiation
Values (general for the basic education): human rights, equality, democracy, natural diversity, preservation of environmental viability, and the endorsement of multiculturalism, responsibility, a sense of community, and respect for the rights and freedoms of the individual; instruction in the different subjects is nondenominational and politically neutral			
	Chemistry Objectives of grades 7-9; lower secondary school	General objectives of the school discipline	Main topics for the discipline
	The tasks of chemistry instruction in the seventh through ninth grades are to expand the pupil's knowledge of chemistry and the nature of chemical	• learn to work safely, following instructions • learn to use research methods typical from the standpoint of acquiring scientific knowledge, these methods including information and communication	**Air and water** • atmospheric substances and their importance to the individual and the equilibrium of nature • water and its properties, such as acidity and alkalinity

	information and guide the pupil in thinking characteristic of the (natural) sciences, in acquiring knowledge, and in applying that knowledge in different life situations. The instruction provides the pupil with material essential from the standpoint of personality development and the formation of a modern world view, and helps the pupil comprehend the importance of chemistry and technology in everyday life, the living environment, and society. Chemistry instruction must provide the pupil with the ability to make everyday choices and to discuss, in particular, issues of energy production, the environment, and industry; it must also guide the pupil in taking responsibility for the environment. The instruction relies on an experimental approach in which the starting point is the observation and investigation of substances and phenomena associated with the living environment. The pupil progresses from that point to the interpretation, explanation, and description of	technology; and to evaluate the reliability and importance of the knowledge • learn to carry out scientific investigation and to interpret and present the results • learn about processes associated with the cycle of substances and the life-cycles of products, and the importance of those processes to nature and the environment • learn to know about the physical and chemical concepts that describe the properties of substances and learn to apply those concepts • learn concepts and models that describe the chemical bonds and structure of matter • learn to describe and model chemical reactions with the aid of reaction equations • learn to apply their knowledge to practical situations and choices • learn to know about the importance of chemical phenomena and applications to the individual and society.	• flammability of substances; the combustion reaction; its description with the symbolic language of chemistry; the properties of combustion products and effects on the environment **Raw material and products** • key elements and compounds to be found in the earth's crust and their properties, and the manufacture, use, sufficiency, and recyclability of products • electrochemical phenomena, the electrochemical cell, and electrolysis, and their applications • symbolic designation, classification and distinction of elements and compounds; comparison of reaction rates • interpretation of reaction equations and the balancing of simple reaction equations • explanation of the properties and structures of elements and compounds with the aid of an atomic model or the periodic table **Living nature and society** • photosynthesis and combustion; energy sources • oxidation reactions and reaction products of organic compounds such as alcohols and carboxylic acids, and the properties and uses of these products • hydrocarbons, the petroleum-refining industry, and its products • carbohydrates, proteins, and lipids; their composition and importance as nutritional substances and industrial raw materials • washing and cosmetic materials; textiles

	phenomena, and to modelling both the structure of matter and chemical reactions with the symbolic language of chemistry. The experimental orientation must help the pupil to grasp the nature of science and to adopt new scientific concepts, principles, and models; it must develop manual skills and abilities for experimental work and cooperation and stimulate the pupil to study chemistry.		
Values (general for basic education): human rights, equality, democracy, natural diversity, preservation of environmental viability, and the endorsement of multiculturalism, responsibility, a sense of community, and respect for the rights and freedoms of the individual; instruction in the different subjects is nondenominational and politically neutral			
	Mathematics Objectives of grades 6-9; primary school and lower secondary school	General objectives of the school discipline	Main topics for the discipline
	The core task of mathematics instruction in the sixth through ninth grades is to deepen understanding of mathematical concepts and furnish adequate basic capabilities encompassing the modelling of everyday	• learn to trust themselves, and to take responsibility for their own learning in mathematics • come to understand the importance of mathematical concepts and rules, and to see the connections between mathematics and the real world • learn to perform calculations and solve mathematical problems • learn to think logically and creatively • learn to apply various methods to the acquisition and processing of information • learn to express their thoughts unambiguously and to justify their actions and conclusions • learn to present questions and conclusions on the basis of	**Thinking skills and methods** • functions that demand logical thinking, such as classification, comparison, organization, measurement, constructing, modelling, and looking for and presenting rules and correlations • interpretation and use of concepts needed in drawing comparisons and correlations • interpretation and production of mathematical texts • introduction to proof: justified conjectures and experiments, systematic trial-and-error

	mathematical problems, the learning of mathematical models of thinking, and practice with remembering, focusing, and precise expression.	observations • learn to perceive regularities • learn to work in a sustained, focused manner, and to function in a group.	method, demonstrating incorrectness, direct proof • solving combinatorial problems by different methods • use of tools and drawings that assist thinking history of mathematics **Numbers and calculations** • strengthening basic calculation skills • natural numbers, whole numbers, rational numbers, real numbers • opposite numbers, absolute values, reciprocals • time calculations, time intervals • prime numbers, division of numbers into prime factors, rules for divisibility of numbers • reduction of fractions, conversion of fractions to higher terms, and presentation of decimal fractions as common fractions • multiplication and division with fractions, including decimal fractions • reduction of expressions • ratio and proportionality • strengthening the concept of percentage, percentage calculation • rounding and estimation; using a calculator • powers using whole-number exponents • concept of the root, square-root calculations **Algebra** • the expression and its reduction • the exponential expression and its reduction • concept of the polynomial; addition, subtraction

			and multiplication of polynomials • concept of the variable; calculating the value of an expression • equation, inequality, domain, solution set • solving a first-degree equation • solving an incomplete quadratic equation • proportion • pairs of equations and their resolution algebraically and graphically • study and formulation of number sequences **Functions** • observing correlation and presenting it by means of variables • concept of the function • presenting a set of coordinates in a coordinate system • interpreting simple functions and drawing their graphs in a coordinate system • investigating the graph of a function: the function's null point, largest and smallest value, increase, and decrease • the linear function • direct and inverse proportionality **Geometry** • relationships between angles • concepts related to triangles and quadrangles • regular polygons • the circle and related concepts • calculating the perimeter and area of plane figures

			• naming and classifying three-dimensional figures • calculating the volume and surface area of a three-dimensional figure • similarity and congruence • geometric construction • depictions of congruence: reflections, rotation, and transformation • Pythagorean theorem • relationships between the triangle and the circle • trigonometry and solving the right triangle **Probability and statistics** • concept of probability • frequency and relative frequency • determining the average, mode, and median • concept of dispersion • interpretation of diagrams • gathering and adapting information, and presenting it in a usable form
Values (general for basic education): human rights, equality, democracy, natural diversity, preservation of environmental viability, and the endorsement of multiculturalism, responsibility, a sense of community, and respect for the rights and freedoms of the individual; instruction in the different subjects is nondenominational and politically neutral			
	Physics Objectives of grades 10-12 upper secondary school	General objectives of the school discipline	Main topics for the discipline
	Physics is an empirical natural science which aims to understand and explain the basic structure and phenomena	The objectives of instruction in physics are for students to • become aware of humans as part of nature and understand the significance of physics in modeling natural phenomena; • understand the significance of experimentation and theoretical	Compulsory course **1. Physics as a natural science (FY1)** • significance of physics at different stages of history and today; • structures of and basic interactions between matter

	of nature, using information derived from nature by means of experimental methods. The aim is to discover universally applicable laws of nature and to represent these in the form of mathematical models. The experimental nature of physics may - depending on the theme, stage of instruction and tools - be implemented through students' own independent work, demonstrations from teachers or study visits, videos or lectures. Experimentation will be used to support students as they absorb new scientific concepts, principles and models. Studies in physics will develop students' experimental and co-operation skills. Experimentation will help students to perceive the nature of the natural sciences and will support	speculation in the formation of knowledge in the natural sciences; • perceive the significance of physics to science, art, technology, communication and economic life as well as in people's everyday environments; • actively and responsibly contribute to the creation of a safe and healthy environment; • structure their understanding of the building blocks and phenomena of nature by means of the concepts and principles of physics; • be capable of solving problems of natural science and technology by making creative use of the laws and concepts of physics; • acquire and process information together with other students in the same way as expert communities; • plan and take simple measurements and be capable of interpreting, assessing and applying the results; • make use of various sources to acquire information and be capable of presenting and publishing information in a diverse manner, also using technical aids; • examine the significance of physics to individuals and society as appliers of physics information, acquaint themselves with physics applications and their skilled, ethical and controlled use in product creation and facilitation of everyday life and obtain capabilities to understand the effects of technological applications.	and the universe; • absorption and release of energy, in particular radiation, in natural and artificial processes; • experimentation and modelling as the foundation for building up physical knowledge; measurements, presentation of results and assessment of their reliability; • force as a cause of changes in motion; • basic concepts required to describe motion and graphical representation of motion. Specialisation courses **2. Heat (FY2)** • changes of state in gases and thermal expansion; • pressure, hydrostatic pressure; • heating and cooling of bodies; phase transitions and thermal energy; • mechanical energy, work, power and efficiency; • the main laws of thermodynamics; internal energy; • energy resources. **3. Waves (FY3)** • harmonic forces and vibrations; • generation and propagation of waves; • interference, diffraction and polarisation of waves; • reflection, refraction and total reflection; • light, mirrors and lenses; • sound, health effects of noise and protection against loud sounds. **4. Laws of motion (FY4)** • motion models and Newton's laws; • action-at-a-distance and contact forces, in particular

	development of their scientific thinking. Students will learn to examine the structures and phenomena of nature in the light of their existing knowledge and ideas. They will learn to become aware of and question their preconceptions and specify their world view on the basis of newly acquired knowledge. Students will learn to plan experiments in groups and to discuss information or material acquired through experimentation, its processing and modeling and the assessment of its reliability. The group will learn to share new information. Studies in the natural sciences employ experimental methods, different sources of information and different ways of processing information. The primary source of physical		forces resisting motion; buoyancy; • conservation of momentum and impulse; • kinetic and potential energy and the principle of work; • vibration energy. **5. Rotation and gravitation (FY5)** • moments and rotational equilibrium; • models of rotation, uniform and uniformly accelerated rotation; • the rotational equation of motion; • conservation of angular momentum; • rotation energy; • circular motion and its acceleration; • gravitation and gravitational motion; • projectile and planetary motions; • satellites and their uses. **6. Electricity (FY6)** • electric cells, flow of electrical current in metallic conductors; • measuring potential difference and current; • Ohm's law; • Joule's law; • resistance, resistor elements and Kirchhoff's laws; • Coulomb's law, homogeneous electric fields and matter in electric fields; • condensers, connections and energy; • flow of electrical current in semiconductors, such as diodes. **7. Electromagnetism (FY7)** • magnetic force, magnetic fields and matter in

	information is nature. At school, additional sources of scientific information include textbooks and non-fiction, digital information resources and experts in the field.		magnetic fields; • charged particles in homogeneous electric and magnetic fields; • the law of induction and Lenz's law; • induction phenomena - eddy currents, generators and self-induction; • energy transfer by means of electrical current; • measuring effective voltage and current and determining the frequency dependence of impedance; • oscillator circuits and antennas, electromagnetic communication; • electrical safety; • the energy industry. **8. Matter and radiation (FY8)** • electromagnetic radiation; • X-radiation; • radiation of black bodies; • the photoelectric effect; • the particle nature of radiation and the wave nature of particles; • atomic models, such as Bohr's model of the atom; • quantisation, line spectrum, atomic energy states and the energy level diagram; • the structure of an atomic nucleus; • radioactivity and radiation safety; • equivalence between mass and energy; • nuclear reactions and nuclear energy; • the smallest particles of matter and their classification.
Values: Students should learn how to treasure, assess and renew their cultural heritage. Students will be educated in tolerance and international co-operation; based on respect for life and human rights; comprises the pursuit of truth, humaneness and justice; promote open democracy, equality			

and well-being. Educational work will place emphasis on co-operation, encouraging interaction and honesty; rights and responsibilities and to grow to assume adult responsibility for their own choices and actions.
Encourage students to recognise conflicts between stated values and reality and to ponder critically the disadvantages and opportunities of Finnish society and international development; become able to form a structured understanding of basic civil rights in Finland, the Nordic countries and the European Union, their meaning in practical terms and ways to uphold and promote them.
Highlight the principles of sustainable development and provide capabilities to face the challenges posed by the changing world. The basic values of upper secondary school are consolidated by the cross-curricular themes, which are value-based positions on current challenges in education and schooling.

	Chemistry Objectives of grades 10-12 upper secondary school	General objectives of the school discipline	Main topics for the discipline
	The purpose of instruction in chemistry is to support development of students' scientific thinking and modern world view as part of a diverse all-round education. Instruction will convey an image of chemistry as one of the key natural sciences, which studies and develops materials, products, methods and processes in order to promote sustainable development. Through examination of substances, their structures and properties and reactions between substances, instruction	The objectives of instruction in chemistry are for students to • understand the most important basic concepts of chemistry and realize the connections of chemistry with everyday phenomena and with the well-being of man and nature; • be able to seek and process information about chemical phenomena and properties of substances important in terms of life and the environment by means of experimentation and other active information acquisition methods and to assess the reliability and importance of such information; • learn how to plan and carry out experiments concerning different phenomena, taking safety considerations into account; • be able to interpret, assess, present and discuss information that they have acquired through experimentation or by other means; • familiarize themselves with the opportunities provided by information and communications technologies as tools for information acquisition and modeling; • familiarize themselves with modern technology in industry and	Compulsory course **1. The chemistry of man and of the living environment (KE1)** • groups of organic compounds, such as hydrocarbons, organic oxygen compounds, organic nitrogen compounds, and their properties and applications; • chemical bonds and the polarity of organic compounds; • different types of mixtures, amounts of substances; proportions; • redox reactions of organic compounds and proton transfer reactions. Specialisation courses **2. The microworld of chemistry (KE2)** • properties of elements and the periodic system; • electronic structure and atomic orbitals; • determination of oxidation numbers and compound formulae; • chemical bonds, binding energy and properties of substances;

	will help students to understand everyday life, nature and technology and the significance of chemistry to the well-being of man and nature. Chemistry instruction is characterized by observation and experimental study of the properties of chemical phenomena and substances, the interpretation and explanation of phenomena by means of models and structures, description of phenomena using chemical notation and by modeling and mathematical processing of phenomena. Students will be guided to develop their skills in and knowledge of chemistry and all areas of their personality through diverse working and assessment methods. The implementation of chemistry instruction will pay attention to students' study skills and create a	environmental engineering; • know how to use their chemical knowledge as consumers in order to promote health and sustainable development and in discussions and decision-making processes concerning nature, the environment and technology; • obtain experiences that will arouse and intensify their interest in chemistry and chemistry studies.	• hybridisation of atomic orbitals and bonding and conformations of organic compounds; • isomerism. **3. Reactions and energy (KE3)** • symbolic representation of chemical reactions; • inorganic and organic reaction types, mechanisms and applications; • stoichiometric calculations and the Ideal Gas Law; • energy changes in chemical reactions; • reaction rates and factors affecting the rates. **4. Metals and materials (KE4)** • electrochemical series, standard electrode potentials, chemical cells and electrolysis; • redox reactions; • metals and non-metals and their oxygen and hydrogen compounds; • biopolymers, synthetic polymers and composites. National core curriculum for upper secondary schools 2003 159 **5. Reactions and equilibrium (KE5)** • reaction equilibria; • acid-base equilibrium, strong and weak acids and bases, buffer solutions and their significance; • solubility and solubility equilibrium; • graphical presentations of equilibrium.

	positive image of chemistry and chemistry studies.		
Values: Students should learn how to treasure, assess and renew their cultural heritage. Students will be educated in tolerance and international co-operation; based on respect for life and human rights; comprises the pursuit of truth, humaneness and justice; promote open democracy, equality and well-being. Educational work will place emphasis on co-operation, encouraging interaction and honesty; rights and responsibilities and to grow to assume adult responsibility for their own choices and actions. Encourage students to recognise conflicts between stated values and reality and to ponder critically the disadvantages and opportunities of Finnish society and international development; become able to form a structured understanding of basic civil rights in Finland, the Nordic countries and the European Union, their meaning in practical terms and ways to uphold and promote them. Highlight the principles of sustainable development and provide capabilities to face the challenges posed by the changing world. The basic values of upper secondary school are consolidated by the cross-curricular themes, which are value-based positions on current challenges in education and schooling.			
	Mathematics Objectives of grades 10-12 upper secondary school	General objectives of the school discipline	Main topics for the discipline
	Mathematics, advanced syllabus The role of instruction in the advanced mathematics syllabus is to provide students with the mathematical capabilities required in vocational studies and higher education. In advanced mathematics studies, students will be given opportunities to adopt mathematical concepts and methods and to learn to understand the nature of	The objectives of instruction in the advanced mathematics syllabus are for students to • become accustomed to persistent work, thus learning to trust their own mathematical abilities, skills and thinking; • find courage to adopt experimental and exploratory approaches, discover solutions and assess these critically; • understand and be able to use mathematical language, so as to be capable of following mathematical presentations, reading mathematical texts and discussing mathematics, and learn to appreciate precision of presentation and clarity of argumentation; • learn to perceive mathematical knowledge as a logical system; • develop their skills to process expressions, draw conclusions and solve problems;	Compulsory courses **1. Functions and equations (MAA1)** • power functions; • solving power equations; • roots and fractional powers; • exponential functions. **2. Polynomial functions (MAA2)** • products of polynomials and the binomial theorem; • polynomial functions; • quadratic and higher-order polynomial equations; • examining the number of roots in quadratic equations; • factorisation of quadratic polynomials; • solving polynomial inequalities.

	mathematical knowledge. In addition, instruction will aim to give students a clear understanding of the significance of mathematics to the development of society and of its applications in everyday life, science and technology.	• gain practice in processing information in a way characteristic of mathematics, become accustomed to making assumptions, examining their validity, justifying their reasoning and assessing the validity of their arguments and the generalisability of the results; • gain practice in modeling practical problem situations and making use of various problem-solving strategies; • know how to use appropriate mathematical methods, technical aids and information sources.	**3. Geometry (MAA3)** • similarity of figures and bodies; • sine and cosine rules; • geometry of a circle, its parts and straight lines related to it; • calculating lengths, angles, areas and volumes related to figures and bodies. **4. Analytical geometry (MAA4)** • equations of sets of points; • equations of straight lines, circles and parabolas; • solving absolute value equations and inequalities; • solving equation systems; • distance of a point from a straight line. **5. Vectors (MAA5)** • basic properties of vectors; • addition and subtraction of vectors and scalar multiplication of vectors; • the scalar product of vectors in the system of co-ordinates; • straight lines and planes in space. **6. Probability and statistics (MAA6)** • discrete and continuous statistical distributions; • distribution parameters; • mathematical and statistical probability; • combinatorics; • rules for calculating probabilities; • discrete and continuous probability distributions; • expected values of discrete distributions; • normal distribution.

			7. The derivative (MAA7) • rational equations and inequalities; • limits, continuity and derivatives of functions; • differentiation of polynomial functions and of the products and quotients of functions; • examining the behaviour of a polynomial function and determining its extreme values. **8. Radical and logarithmic functions (MAA8)** • radical functions and equations; • exponential functions and equations; • logarithmic functions and equations; • derivatives of composite functions; • inverse functions; • derivatives of radical, exponential and logarithmic functions. **9. Trigonometric functions and number sequences (MAA9)** • directed angles and radians; • trigonometric functions, including their symmetric and periodic properties; • solving trigonometric equations; • derivatives of trigonometric functions; • number sequences; • recursive number sequences; • arithmetic progressions and sums; • geometric progressions and sums. **10. Integral calculus (MAA10)** • integral functions; • integral functions of elementary functions; • the definite integral;

			• calculating areas and volumes. Specialisation courses **11. Number theory and logic (MAA11)** • formalisation of statements; • truth-values of statements; • open statements; • quantifiers; • direct, contrapositive and indirect proofs; • divisibility of integers and division equations; • Euclidean algorithm; • prime numbers; • the Fundamental Theorem of Arithmetic; • congruence of integers. **12. Numerical and algebraic methods (MAA12)** • absolute and relative errors; • Newton's method and iteration; • polynomial division algorithms; • polynomial division equations; • rates of change and areas. **13. Advanced differential and integral calculus (MAA13)** • examining the continuity and differentiability of functions; • general properties of continuous and differentiable functions; • the limits of functions and number sequences in infinity; • improper integrals.

	Mathematics, basic syllabus The role of instruction in the basic mathematics syllabus is to provide students with capabilities to acquire, process and understand mathematical information and to use mathematics in different situations in life and in further studies.	The objectives of instruction in the basic mathematics syllabus are for students to • be able to use mathematics as an aid in everyday life and social activities; • obtain positive learning experiences when working with mathematics and learn to trust their own abilities, skills and thinking; find courage to engage in experimental, exploratory and inventive learning; • acquire such mathematical skills, knowledge and capabilities that will create a sufficient foundation for further studies; • internalise the significance of mathematics as a tool which can be used to describe, explain and model phenomena and to draw conclusions; • form an overview of the nature of mathematical knowledge and its logical structure; • gain practice in receiving and analysing information provided by the media in a mathematical form and in assessing its reliability; • acquaint themselves with the significance of mathematics in the development of culture; • learn to use figures, formulae and models in support of thinking.	Compulsory courses **1. Expressions and equations (MAB1)** • linear dependence and proportionality between quantities; • converting word problems into equations; • solving equations graphically and algebraically; • interpreting and assessing solutions; • quadratic polynomial functions and solving quadratic equations. **2. Geometry (MAB2)** • similarity of figures; • right-angled triangle trigonometry; • Pythagoras' theorem; • determining areas and volumes of figures and bodies; • use of geometrical methods in the co-ordinate system. **3. Mathematical models I (MAB3)** • applying linear and exponential models; • solving power equations; • solving exponential equations using logarithms. **4. Mathematical analysis (MAB4)** • derivatives of polynomial functions; • examining the sign and behaviour of a polynomial function; • determining the maximum and minimum of a polynomial function; • graphical and numerical methods. **5. Statistics and probability (MAB5)** • determining the parameters of continuous and

			discrete statistical distributions; • normal distribution and standardisation of distributions; • combinatorics; • the concept of probability; • use of rules for calculating probabilities and of the models illustrating these. **6. Mathematical models II (MAB6)** • linear equations with two variables; • solving pairs of linear equations; • solving inequalities with two variables graphically; • linear programming; • number sequences; • arithmetic and geometric progressions and sums. Specialisation courses **7. Commercial mathematics (MAB7)** • index, cost, money transaction, loan, tax and other calculations; • mathematical models applicable to economic situations, using number sequences and sums. **8. Mathematical models III (MAB8)** • determining trigonometric functions by means of the unit circle; • radians; • solving trigonometric equations of the form $f(x) = a$; • graphs of functions of the form $f(x) = A \sin (bx)$ as modellers of periodic phenomena; • the concept of the vector and the principles of basic vector operations;

			• component representation and scalar product of vectors in the system of co-ordinates; • examining the points and angles of two- and three-dimensional co-ordinate systems by means of vectors.
Values: Students should learn how to treasure, assess and renew their cultural heritage. Students will be educated in tolerance and international co-operation; based on respect for life and human rights; comprises the pursuit of truth, humaneness and justice; promote open democracy, equality and well-being. Educational work will place emphasis on co-operation, encouraging interaction and honesty; rights and responsibilities and to grow to assume adult responsibility for their own choices and actions. Encourage students to recognise conflicts between stated values and reality and to ponder critically the disadvantages and opportunities of Finnish society and international development; become able to form a structured understanding of basic civil rights in Finland, the Nordic countries and the European Union, their meaning in practical terms and ways to uphold and promote them. Highlight the principles of sustainable development and provide capabilities to face the challenges posed by the changing world. The basic values of upper secondary school are consolidated by the cross-curricular themes, which are value-based positions on current challenges in education and schooling.			

POLAND					
Objectives of the science curriculum area	**School discipline**	**General objectives of the school discipline**		**Main topics for each discipline**	
		Lower secondary	Upper secondary	Lower secondary	Upper secondary
School ensures: • teaching and learning accurate and free speech, writing, and reading comprehension • learning required notions and acquiring sound knowledge on a level enabling further education on the next stage of education, • arriving at comprehending instead of only memorizing the subject content • developing the abilities to discern various kinds of relationships such as cause and effect, functional, time and spacer relationships)	Mathematics	EDUCATIONAL GOALS • Learning mathematics basic notions and techniques to an extent that will allow for recognizing their usefulness and making use of them in every-day situations, in particular: 1) systematizing the knowledge of rational numbers as well as acquiring the skills of making calculations on rational and real numbers, powers and roots, 2) using the percentage in practical situations, 3) introduction to algebraic calculus, in particular acquiring the skills to use formula, 4) the skills to resolving linear equations and inequalities and systems of two linear	GOALS • Preparing for aware and full participation in the world issues, in which mathematics models play the key role. • Learning the basic mathematics structures to an extent that will allow recognizing their usefulness and using them in everyday situations, in particular: 1) systematizing the knowledge of real numbers well as acquiring the skills of computing, 2) mastering rules of algebraic calculus, 3) getting students to describe and analyse a correlation and variability using elementary functions, 4) getting to know the structure of the surrounding space through classic geometric features; developing the special imagination, 5) learning elementary methods of the analysis of statistic and random phenomena and their simplest combinatory	• Rational number • Power (natural and integer number exponent) • Roots • Percentage • Algebraic expressions • Equations and inequality • Function graphs • Statistics and introduction to calculus of probabilities • Planes figures • Solid bodies.	• Real number • Algebraic expressions • Equations and inequality • Functions • Sequences • Trigonometry • Plan geometry • Analytical geometry • Stereometry • Elements of the statistics. • Probability and combinatorics.

• developing the abilities to think both analytically and synthetically, • teaching subjects in an integrated way, which leads to better understanding of the world, people and oneself, • learning the principles of personality development and society life, • learning about the nation culture heritage perceived against European culture.		equations and inequalities, using to resolve practical issues. 5) Interpreting basic function graph features, 6) Using classic features of plane figures (Thales and Pythagoras theorems, symmetry; development of spacial imagination 7) Introduction to ordering, reading and interpreting data; teaching random experiments. • Making aware of the need and preparing critical appraisal of the conducted reasoning or calculations results. Making the habit of using definitions and rules. • Making the habit of autonomous searching for information and joint analysis of information coming from various sources.	descriptions • Getting students accustomed to typical mathematics reasoning elements, in particular to using such notions as: assumption, conclusion, proof (an indirect one as well), example and contrexample. • Developing the skill of as well as the need for critical assessment of the conducted way of reasoning or the calculations results. • Developing the habit and need of autonomous acquiring, analyzing and classifying information, stating hypotheses and searching for methods of their verification. • Developing the skills of clear and precise argumentation. SCHOOL TASKS • Ensuring education promoting autonomous, critical and creative thinking, limiting to minimum schematic and "miming" activities. • Ensuring the development of mathematics abilities of students in accordance with their cognitive abilities.		

		• Developing the skills of argumentation and its clearly stating. SCHOOL TASKS • Ensuring education promoting autonomous, critical and creative thinking, limiting to minimum schematic and "miming" activities. • Ensuring the development of mathematics abilities of students in accordance with their cognitive abilities. • Preparing students for autonomously acquiring knowledge at further stages of education and future work. Getting students accustomed to using modern tools (calculators, computers, multimedia) and information sources (school books, dictionaries, maps,	• Preparing students for autonomously acquiring knowledge at further stages of education and future work. Getting students accustomed to using modern tools (calculators, computers, multimedia) and information sources (school books, dictionaries, maps, encyclopedia, the Internet		

		encyclopedia, the Internet).			
Objectives of the science curriculum area	**School discipline**	**General objectives of the school discipline**		**Main topics for each discipline**	
		Lower secondary	Upper secondary	Lower secondary	Upper secondary
School ensures: • teaching and learning accurate and free speech, writing, and reading comprehension • learning required notions and acquiring sound knowledge on a level enabling further education on the next stage of education, • arriving at comprehending instead of only memorizing the subject content • developing the abilities to discern various kinds of relationships such as cause and effect, functional,	Physics	EDUCATIONAL GOALS - providing students the basic laws of nature; - acquiring by students skills in performing experiments, presentation of results, formulating hypotheses and their analysis; - acquiring knowledge necessary to describing physical and astrophysical phenomena with the aid of models and mathematical techniques; - applying physical knowledge in everyday practice; - acquiring skills in the critical use of information resources.	GOALS **Ground level** - existence of laws governing the micro-and macro world; - role of experiment, observation and theories in exploring the nature; - role of computers in creating models and in analysis of experimental results; - preparation of students to intelligent use of information, lead discussion and formulating own opinions; - ability to discuss on different problems in the field of physics and astronomy; - acknowledging the role of physics in technology, medicine, ecology and other fields of human activity. **Extended level** - awareness of physical phenomena in the world, nature and structure of physics and its connection with other branches	Properties of matter. Kinetic theory, phases. Motion and forces. Straight- and curved line motion, oscillatory motion. Mechanical forces and their consequences. Conservation of momentum. Laws of dynamics. Gravitational interactions. Space flights. Work and energy. Mechanical energies. Energy conservation law. Power. First law of thermodynamics. Transmission of information, methods of its realization. Sound waves. Electromagnetic waves. Optical waves. Reflection and refraction of light. Generation of optical images. Colours. The nature of light.	**Ground level** Motion in different frames of reference, its relativity and generality. Maximal speed of information transmission in nature and its consequences. Relativistic effects. Interactions in the nature, in micro – and macro world. Force fields and their influence on the character of motion. Macroscopic properties of matter and their relation to its microscopic structure. Harmonic oscillator, description of oscillating motion, energy conversions. Order and chaos in the nature. Thermodynamical processes (reversible or not), second law of thermodynamics, entropy. Light as a wave and its role in nature. Quantum model of light. Photoelectric effect, the structure of atom. Spectral analysis. Laser and its applications. Energy – conversions, transmitting. Equivalence of mass and energy. Elements of nuclear physics. Radioactivity – applications and threats. The structure and evolution of the Universe. Galaxies, evolution of stars.

time and spacer relationships), • developing the abilities to think both analytically and synthetically, • teaching subjects in an integrated way, which leads to better understanding of the world, people and oneself, • learning the principles of personality development and society life, • learning about the nation culture heritage perceived against European culture.			of science; - knowledge of experimental and theoretical methods in physics and the role of experiments in its developing; - acquiring knowledge and skills necessary for university studies in science and technology; - abilities in computer applications for creating models and analysis of experimental data.	Electricity and magnetism. Electric charges and their interactions between them. Electric field. Electric circuit for the direct current. Electric current laws. Magnetic field. Magnetic induction. Fabrication and transmission of electric energy Microscopic model of electrical phenomena. The structure of atom. Nuclear energy. Nuclear radiation. Solar system. Elements of cosmology.	Time-space-matter-energy. Wave – particle duality. Unity of micro – and macro world. • Physics and philosophy. Methodology of science. Statistical methods. Tools of modern physics. Modern astronomical observatories. Scientific achievements **Extended level** Motion and forces. Conservation laws. Mathematical description of two-dimensional motion. Field model of gravitational and electromagnetic interactions. Motion of a particle in electric and magnetic fields. Direct current electric circuits. Energy transformations in these currents. Electromagnetic field. Electromagnetic induction. Electromagnetic waves. Oscillatory circuits. Physical foundations of microelectronics and telecommunication. Models of electrical conductivity. Semiconductors, diode, transistor. Analog and digital recording of signals. Thermodynamical phenomena, principles of thermodynamics, phase transitions, processes in gases. Hydrostatic and aerostatic phenomena, examples of applications. A review of models and theories in physics and astronomy.

Objectives of the science curriculum area	**School discipline**	**General objectives of the school discipline**		**Main topics for each discipline**	
		Lower secondary	Upper secondary	Lower secondary	Upper secondary
	Chemistry	***Educational aims*** 1. Acquiring the skills to observe and describe chemical phenomena taking place in the surrounding world. 2. Learning the role of chemistry knowledge in the process of man's processing of the matter. 3. Acquiring the skills and habit of acting in accordance with the principles of both health care of oneself and the environment. ***School assignments*** 1. Forming a way of thinking that leads to understanding of the acquired chemical knowledge and putting it into practice in various everyday situations. 2. Getting students familiar with characteristics of	***Ground level*** ***Educational aims*** 1. Understanding the meaning of the chemical changes happening in the surrounding world. 2. Awakening the role of chemistry in the development of the civilization and the everyday life 3. Perception of the humans' influence on the environment and absorbing the knowledge necessary to perform environmental-friendly activities. ***School assignments*** 1. Forming the research way of thinking, typical for science. 2. Developing the observational ability, concluding from the conducted experiments and formulating the generalizations. 3. Forming the ability to use the acquired chemical knowledge. 4. Preparing the learners to the correct taking advantage of the various sources of information.	1. Substances and chemical changes in the human environment. Metals and non-metals mixtures, air as a mixture of gases, oxygen, nitrogen, features, oxides, air pollution. 2. Atom structure: minute central, electrons, components of a minute central, isotopes. Radioactivity and its diverse consequences. Atoms, ions and molecules, elements and compounds, chemical symbols, valency of elements. Atomic and ionic bonds. 3. Atomic-molecule theory – discreteness of. matter Periodic table of elements – the way of systematizing of elements.	***Ground level*** 1. Contemporary, simplistic model of the atom structure. Isotopes. Natural radioactivity. 2. The relation between the atom structure and the elements location in the periodic table of elements and their features. 3. The relation of the physical and chemical features of the substances from the type of the chemical bond. 4. Chemical reactions and physical phenomena. The quantity principles governing the chemical changes. The reactions of synthesis, analysis and exchange. 5. The mol. The molar interpretation of the chemical transformations. Molar volume. 6. The chemical reactions speed. 7. Endo- and exothermic reactions 8. Simple reactions of oxidizing-reduction and their role in the nature and in the everyday life 9. Saturated and unsaturated solutions. The ways of formulating the solution concentration -percentage and molar concentration.

		chemical substances and the safe way of handling them. 3. Enabling students to acquire knowledge and skills that are both practical and adequate to the requirements of further education.	5. Forming the learner's behaviour according to the rules of taking care of their own health and the protection of the environment. **Extended level** ***Educational aims*** 1. Deepening the chemical knowledge to a degree necessary to the future learning. 2. Developing the ability to plan and realize the experimental works and the interpretation of the previously received works. 3. Developing the sense of responsibility for their own safety and the protection of the environment. ***The school assignments*** 1. Supporting the ability of self-education through gaining and gathering the information from various sources. 2. Accustoming the learners to selecting and evaluating of the gained information. 3. Introducing the learners to the laboratory practice through conducting demonstrations and doing experiments on their own. 4. Preparing the learners to plan	4. Weight stoichiometric relations in chemical compounds and chemical reactions - atomic mass, molecular mass, law of definite proportions, law of conservation of mass, 5. Chemical reactions and chemical equations. 6. Water and water solutions – civilization threats resulting from pollution. 7. Solutions, solubility, percentage solution concentration – basic calculations. 8. Types of non-organic compounds: acids, alkalis, hydrogen oxides, ionic dissociation, solutions pH – qualitatively, reactions between acidic and alkaline substances, basic features and applying chosen salts. 9. Mineral recourses products: coal, oil, gas oil, limestone, plaster, glass. 10. Carbon and its	10. Electrolytic dissociation. The reactions in the water solutions of the electrolytes - the reactions of unreacting and precipitating of the residues. 11. The features of the chosen metals and non-metals. 12. Saturated, unsaturated, aromatic carbohydrogens - the structure and features 13. The sources of carbohydrogens in the nature. 14. Single functional derivatives of the carbohydrogens -obtaining and features 15. The most important, multifunctional derivatives of the carbohydrogens - appearing, features, applying and their role in the humans life. 16. The chemistry in the economic, social life and the environment protection. The practical applying of the known chemical substances and the risk caused by the inappropriate usage of them. **Extended level** 1. Contemporary model of the atom structure - the elements of the quantum mechanics in the qualitative point of view. Isotopes. The natural and artificial radioactivity. 2. The periodic table of elements. The relation between the atoms structure and the features of the elements and their position in the periodic table of elements.

			the research and the interpretation of the received outcomes on the basis of the gained chemical knowledge and from the allied areas.	compounds. Simple saturated and unsaturated carbohydrogens alcohols, carboxylic acids, soaps, esters, fats, sugars, proteins as basic components of living organisms, plastics. 11. The effect of certain substances on an individual: medicines, poison, alcohol, drugs, pesticides.	The elements allotropy. 3. Ionic, covalence, covalence polarized, dipolar bonds. The relation between the features of the compounds and their structure. 4. The chemical balance. The permanence of the balance. The rule of contrariness. 5. The mol. The molar interpretation of the chemical transformations. The Clapeyron's equation. The natural and standard conditions. 6. The speed of the chemical reactions. The row of reactions. 7. Endo and exothermic reactions. Catalysts and examples of catalythic reactions. 8. Reactions of oxidizing- reduction. Galvanic cell and their applying. 9. The SEM of the cell. Electrolysing of the water solution of electrolytes and melted salts. 10. The rights of electrolysing. The electrochemical corrosion and the ways of preventing it. 11. The solutions. Solubility. The converting of the solutions concentration. 12. The systematics of the non-organic compounds. Oxides, hydrogenoxides, acids and salts- naming, receiving, features 13. The characteristic of the most important elements of the s, p, d blocks of the periodic table of elements. The

					changeability of the features of the compounds in groups and periods. 14. Strong and weak electrolytes. The degree and the permanence of the dissociation. The Oswalds' Law of Diluting, the solution ph, the indicators. The reactions in the water solutions of the electrolytes - the reactions of unreacting and precipitating of the residues and the reaction of the hydrolysis. 15.The saturated, unsaturated and aromatic carbohydrogens- naming and features. The homological row. The constitutional and geometric isomery. 16. The occuring of the carbohydrogens in the nature. The altering of the oil. 17. The single-functional derivatives of the carbohydrogens. Alcohols, phenols, aldehydes, cetones, amines, carboxilic acids and their derivatives- structure, naming, receiving and features. 18. Multifunctional derivatives of the carbohydrogens. Aminoacids, peptides and proteins, fats, the most important sugars and nucleic acids- appearing, features and their value in humans life. 19. The phenomenon of the optical isomery. 20. Polymeric plastic- structure and applying. 21. The consequences of the inappropriate use of the chemical substances.

ROMANIA					
Objectives of the science curriculum area	**School discipline**	**General objectives of the school discipline**		**Main topics for each discipline**	
		Lower secondary	Upper secondary	Lower secondary	Upper secondary
	Mathematics	• Knowledge and understanding of the mathematical concepts, terminology and calculus procedures specific for the field of mathematics • Development of the exporation/ investigation and problem solving capacity • Development of the communication capacity through using the mathematical language • Development of interest and motivation for study and application of mathematical knowledge in a variety of contexts.	• Identification of data and mathematical relations and their correlation in function of the context they were defined in • Mathematical discourses quantitative, qualitative, structural and contextual data processing • Use of mathematical algorithm and concepts for the local and global description of a given situation • Expression of mathematical quantitative and qualitative characteristics of a given situation and of the algorithms for its processing • Analysis and interpretation of mathematical characteristics of a problem based situation • Mathematical modeling of diverse problematic situations, through the integration of different fields knowledge* • Generalisation of certain properties through modification of initial context of problem definition or through algoritms generalisation* * for specialised highschools	Natural numbers Rational numbers Integer numbers Real numbers Algebraic calculus Fractions and proportions Equations and systems Equations and Inequations Functions Elements of geometry and measurement units Figures and geometric solids Straight line Angles Congruent triangles Perpendicularity Parallelism Properties of triangle Patrulaters	Mathematic sets and elements of mathematical logic Functions. Strings. Functions. Graphics. *Linear function* *Quadratic function* The quadratic function's graph and its properties Planar vectors Collinearity, concurrence, parallelism – vectorial calculus in plane geometry Applications of trigonometry in geometry *Elements of trigonometry* *Applications of trigonometry and scalar product of vectors in plane geometry** *(only for the profiles with 4 hours of Mathematics per week).* Real numbers Functions and equations Financial Mathematics Geometry • Counting methods • Statistics • Graphs* (for humanist profiles) Elements of matrix calculus and systems of linear equations Matrices

				Elements of data organisation Similarity of triangles Metric relations in the right-angled triangle Circle Relations between points straight lines and geometric planes Orthogonal projections to plane Area and volume calculus	Determinants *Systems of linear equations* *Elements of Mathematical Analysis* *Limits of functions* *Continuous functions* *Derivable functions* *Study of functions with derivatives* (for positive sciences profiles)*
		Values: independent, creative, open, objective thinking, curiosity and imagination in problem solving, tenacity, perseverance and concentration capacity, habit of using the mathematical concepts and methods in solving daily life problems, motivation for study of mathematics as a relevant field for social and professional life			
	Physics	- Knowledge and understanding on the physics phenomenon, on the terminology, concepts and field specific methods - Development of the exploration/ investigation and experimenting capacity, through the use of a set of physics instruments and procedures - Development of	- Defining and recognition of Physics concepts - Exploration and guided experimentation of physical phenomenon and processes - Theoretical and applicative problems solving - Explanation of physical phenomenon by using a specific language through modeling and abstractisation - Transferring and integration of Physics knowledge and methods for their application in natural sciences and technologies	Physical measures. Classification. Ordering Properties Measuring. Physical measures Determining the value of a physical measure Mechanical phenomena Motion and Rest Inertia Interaction Thermal phenomena Heating. Cooling. Dilatation Electrical and magnetic phenomena	Principles and laws of classical mechanics Variation theorems and conservation laws in mechanics Elements of Statics Geometrical optics Reflection and refraction of light Thin lenses Eye Optical instruments Principles and laws of Newtonian Mechanics Motion & Rest Principle I. Principle II. Principle III. Hooks Low. Wire tension. Law of sliding friction Universal attraction Law

		the analysis and problem solving capacity - Development of the communication skills related to the use of Physics specific language - Development of a critical attitude towards the effects of science on the technological and social development and of the interest for the environmental protection	Values: Care for the environment, interest for rational argumentation, development of tolerance towards the oppinions of others, curiosity for the new openings in the filed of science, interest for the technological, scientific and natural environment information, curiosity for the simulation and modeling of the natural phenomenon through experimentation, interest for the way ideas and theories develop in nature sciences	Magnets. Magnetic interactions Electric circuit. Electric current Electric current effects Voltage Hazards related to the use of electrical systems Optical phenomena Light sources Propagation of light Methods used to study physics Light and sound Force - The vector measure The mechanical balance of the bodies Mechanical work and mechanical energy Thermal phenomena Hydrokinetics Heat Change of the aggregation state Electric charge Electrical network Electromagnetism Radiation and radiation protection Nuclear Energetics	Variation theorems and conservation laws in mechanics Mechanical work. Power Theorem of kinetic energy variation of the material point Gravitational and *elastic potential energy Law of conservation of mechanical energy *Impulse variation theorem *Impulse conservation law Elements of Statics Translation balance Rotation balance Elements of thermodynamics Production and use of direct current Production and use of alternating current Oscillations and magnetic waves. Mechanic oscillator. Coupled mechanical oscillators. Mechanical waves. Oscillations and electromagnetic waves Optic waves (*) Elements of chaos theory Geometrical Optics. Wave Optics Special Theory of Relativity Photonic Optics and elements of Quantum Physics Physics of atoms Physics of nucleus

	Chemistry	Knowledge and understanding on the Chemistry phenomenon, on the terminology and field specific concepts Development of the exploration/ investigation and experimenting capacity and Chemistry problem solving capacity Development of the communication skills through the use of Chemistry specific language Development of values and attitudes regarding the impact of the Chemistry on nature and society	Explaining of certain phenomenon, processes and procedures of the daily life Investigation of the behaviour of certain chemical substances and chemical systems Problem solving in order to establish relevant correlations, by proving deductive and inductive reasoning Communication on understanding of concepts in problem solving, explanatory discourses, in conducting investigations and in reporting the results Evaluation of consequences of processes and actions of chemical products on ones person and on the environment Values: Respect for truth and thorough observation, personal initiative, Interest and curiosity, disposition for the optimization of own performance, skepticism for making generalizations that are not based on observations that are verifiable/ repeatable, openness for the opinions of others and disposition to modify own perspectives in the light of new facts.	Solid. Substance. Mixture Substances structure. Periodic Table Chemical reactions. Mass Law. Chemical calculus Simple substances with practical uses. Complexe substances with practical uses.	Electron shell structure for chemical elements from 1, 2, 3, *4 periods. Connection between the electron shell structure, the placement in the Periodic Table and the properties of chemical elements. The variation of periodic properties of chemical elements from primary groups and 1, 2, 3,*4 periods. Ionic bond. Polar and nonpolar covalent bond. Coordinative bond. Hydrogen bond. Dissolution. Factors involved in dissolution. Solubility. Aqueous solutions of acids (acid strenght) and alkali (alkali strenght). pH. Oxidation-Reduction Reactions. Applications: Daniell cell, lead-acid batery. The corrosion and anticorrosion protection. Ideal Gas law. Introduction in Organic Chemistry. Organic elements. Carbon chain types. Molecular and structure formulas. Organic compounds clasification: hydrocarbons and functional compounds. Fuels: methane, oil fractions, coals. Petroleum: source of organic raw material. Petroleum processing. Alkanes Alkenes Alkynes Aromatic hydrocarbons: benzene, toluene, naphthalene. Halogenation and nitration

					reactions. Alcohols: methanol, ethanol, glycerol. Oxidation of ethanol to acetic acid (in air). Methanol – a potential synthetic fuel. The nitration reaction of glycerol. Carboxylic acids. Surface-active agents: soaps and detergents. Natural and synthetic rubber. Plastics. Natural and synthetic fibers. Natural and synthetic dyes. Paints. Flavors. Essences. Organic compounds with biological action: lipids, proteins,carbohydrates (glucose, saccharose, starch, cellulose). Drugs: sulphamides, antibiotics, acetosalicylic acid, human body interaction. Vitamins: clasification, physiological role, avitaminosis. Organic compounds. Organic compound reactions: substitution, addition, displacement, transposition. Compounds with biological role. Introduction in biochemistry. Aldehydes and ketones, carboxylic compounds. Functional derivatives of carboxylic compounds (amides and esters) Soaps and detergents. Organic compounds with mixt functions: natural aminoacides, monosaccharides, disaccharides.

					Optical isomerism. Natural macromolecular compounds: polisaccharides, proteins. Polyesters and polyamides: polymerisation and polycondensation products. Flavors. Essences. Dyes and drugs (acetosalicylic acid, sulphamide, paracethamole, C vitamin). The pollution due to organic compounds.

At a general analysis of the above detailed curriculum programmes some conclusions may be extracted regarding the types of competences targeted, types of contents and their organisation, types of values and attitudes promoted:

Throughout Europe Science curriculum is focused on:

- Systemic acquisition of knowledge
- Training of the research competences
- Development of a critical attitude towards the effects of science on the technological and social development and of the interest for the environmental protection
- Values such as respect for truth and diversity, respect for individual needs and nature, curiosity and initiative, openness for the opinions of others and disposition to modify own perspectives in the light of new facts.
- Exploration of transversal concepts such as: motion and force, energy and electricity, heat, substances around us, natural structures
- Contents integration either at a thematic level (see for example Finnish curriculum) or at the abilities level (see for example the Spanish curriculum).

I.2.Trends in European countries Science teaching and learning

Trends in Finnish Science curriculum

The Finnish national core curriculum has been formulated on the basis of a conception of learning as an individual and communal process of building knowledge and skills. Learning takes place as purposeful study in a variety of situations: independently, under a teacher's guidance, and in interaction with the teacher and peer group. Learning depends on the learner's previously constructed knowledge, motivation, and learning and work habits. Learning is an active and goal-oriented process that includes independent or collective problem-solving. Learning is situational and opens new possibilities for participating in social activity.

Tools and approaches

The study tools and facilities must be designed and organized so as to allow the employment of diverse study methods and working approaches. The learning environment must also be

equipped so as to support the pupil's development into a member of today's information society, and provide opportunities for the use of computers, other media technology, and, as possibilities allow, data networks.

In instruction versatile working approaches support and guide the pupil's learning. The function of the working approaches is to develop social, learning, thinking, working, and problem-solving skills, and to foster active participation. The approaches must further the development of skills with information and communication technology. They must also provide opportunities for the creative activity, experiences, and play characteristic of the age group in question. The teacher selects the working approaches. It is their task to teach and guide the work and learning of both the individual pupil and the entire group.

Physics and chemistry

The starting point for instruction in physics and chemistry are the pupils' *prior knowledge*, skills and experiences. The instruction relies on an *experimental approach* in which the starting point is the *observation* and *investigation* of substances and phenomena associated with the environment. The purpose of the experimental orientation is to help the pupils both to perceive *the nature of science* and to learn new scientific concepts, principles, and models; to develop skills in experimental work and *cooperation*.

The instruction guides the pupil in *thinking in a manner characteristic of science*, in acquiring and using knowledge, and in evaluating the reliability and importance of knowledge in different life situations. The instruction gives the pupil the ability to discuss and write about questions and phenomena within the realm of physics/chemistry and technology, using appropriate concepts. It also provides capabilities for making everyday choices, especially in matters related to environmental protection and the use of energy resources.

The curriculum is a process curriculum and the formative assessment should be used more than the summative assessment.

Mathematics

The core task of mathematics instruction in the sixth through ninth grades is furnish adequate basic capabilities encompassing the modelling of everyday mathematical problems, the learning of mathematical models of thinking, and practice with remembering, focusing, and precise expression.

Trends in Spanish Science curriculum

Student development must be ultimately targeted towards the acquisition of basic knowledge, scientific preparation and ones ability to use different technologies pertaining to one's field(s) of activity.

In secondary Education, the proposed focus now emphasizes general training, as opposed to specific training; and is focused on the acquisition of basic competences.

These competences are understood in general as the development of one's ability to research, seek out information, analyze it and select it; the ability to learn, create, formulate, as opposed to a mere exercise in memorization.

The new society resulting from the technological revolution and its implications to information-related processes has features that can ensure an unprecedented level of autonomy to education. The development of the cognitive and cultural competencies required for full-fledged human development has now coincided with production-related expectations.
What competencies are we talking about? One's ability to sustain abstract reasoning; the development of systems-based thinking, as opposed to a partial and fragmented understanding of phenomena; creativity, curiosity, the ability to think of multiple alternatives to solve a given scientific problem; in other words, the development of diverging thinking,
Even more, the curricula is focused on the ability to work in teams, the willingness to seek and accept criticism, and the development of critical thinking,

The methodology aims towards providing for mathematics competition and competition on knowledge and interaction with the physical world, insuring activities that allow the approach and problem solving through simple searching, sorting and processing of information. Practical exercises are carried out as well as simple field work or lab experiences.

They prevailing work methodologies for insuring effective learning are:

- Project based learning
- Cooperative Learning methods and strategies.

- Inclusive education methodologies.
- Effective field work, visits to museums of science, industrial facilities, research centers, treatment establishments, waste treatment plants etc.
- Experimental work, handling of laboratory instruments,
- ICT instruments must become a routine: virtual environments, interactive and multimedia which can be accessed through the network.

Student participation in their own learning process is recommended.

Since, some years ago a bilingual program has started in a good percentage of secondary schools, some of these subjects are taught in English in some cases. The general rule is to change the subject taught in English every two school years, in order to avoid that students acquire specific concepts and names only in one language. This is, if they study biology in English one year, next one, they will study it in Spanish, to acquire the specific terminology in both languages.

Curricula also includes science, technology and society, a subject aimed to study the social aspect ot the science and their impact in the past, in the present, and in the future in our society.

Trends in Romanian Science curriculum

New innovative ways of contents structuring

Sciences contents tend to be structured in an increasingly inclusive manner, this tendency being obvious in primary school and less present in secondary level. Yet, within classical science fields integrated topics may be observed, particularly in Chemistry curriculum.

Aims and goals in Sciences school subjects focuse on competences of scientific information processing, research skills, and umanistic values.

Methodology highly recommended is focused on inquiry based learning, experiential learning, discovery based learning.

Teachers are regarded as designers of reach learning situations and guiders in knowledge construction.

Trends in Polish Science curriculum

There are three goals that the lower- and higher-secondary school education wants to achieve:

1) To allow students to acquire a defined knowledge scope of facts, principles, theories and practice
2) To make it possible for students to acquire skills necessary to use the acquired knowledge while doing activities and solving problems;
3) To form attitudes ensuring efficient and responsible functioning in the contemporary world.

New methodologies that are suggested

The way to achieve those goals is complementing traditional teaching and learning methods with new methods with the stress on the following:

1) Problem solving approach (e.g. projects),
2) Applying the functional teaching, in accordance with the student's mental development stages,
3) Polisensory teaching with a wide use of multimedia and experiment

New teaching behaviours

The teaching process should take into account students' individual learning styles as well as their special education needs. The designed tasks should take in consideration students experience as well make them search for and use the knowledge and skills taken from both other school subjects and everyday life. Indispensable is developing the skills of defining one's education needs, learning styles and group work.

Teachers of all subjects should make use of school libraries and cooperate with school librarians with the aim of overall preparation of their students to carry out self-study as well as intentional searching for, selecting and using information.

New roles for the students

The student is an active subject of the educational process. According to the constructivism theory students construct the structure of their knowledge themselves. The basic skills connected directly or indirectly with science, which should be mastered by students are as follows:

1) Reading – understood as a skill to comprehend, make use of and process reflectively texts among which are culture texts – leading to the achievements of one's own goal, personality development as well as active participation in society life;
2) Mathematic reasoning – a skill of using mathematics tools in everyday life situations as well as of forming views based on mathematic reasoning;
3) Scientific reasoning – a skill of using scientific knowledge to identify and solve problems as well to make conclusions based on empirical observations concerning nature and society;
4) The skill to communicate in a native as well as foreign languages, both in a spoken and written form;
5) The skill to use efficiently new information and communication technology;
6) the skill to search for, select and critically analyse information;
7) the sill to identify one's educational needs and learning styles;
8) the skill of group work .

New ways of evaluation

The evaluation of students' achievements is two-dimensional:

1. In-school evaluation based on school curriculum requirements (an extended curriculum is possible) is to a great extent of a forming character, stresses the knowledge accumulation as well as students' skills, promotes students' self-evaluation.
2. Examinations based on curriculum requirements is mainly of a summarizing character with its aim to form a system monitoring students' knowledge acquisition and skills after each education phase; for school results analysis it uses educational methodology of added value.

New technologies and materials

The education process should be widely assisted by new technologies which allow for the common usage of multimedia, such as the computer, projector, interactive board, DVD player, etc. It is essential to use the computer as a teaching and learning tool for subjects other than computer science.

Achieving educational goals should be assisted by school libraries with updated sources, in the form of both books and multimedia. Intentional and selective use of the Internet should be its adequate completion.

E-learning is recommended to play a more significant role in education, being a component of the traditional teaching and learning (blended learning).

In conclusion, here are some of the trends that are common to European countries involved in the VI project:

- Learning is regarded as an individual and common process of building knowledge and skills
- Learning is situational and opens new possibilities for participating in social activity
- Learning is focused on competences: ability to sustain abstract reasoning; the development of systems-based thinking, as opposed to a partial and fragmented understanding of phenomena; creativity, curiosity, the ability to think of multiple alternatives to solve a given scientific problem; in other words, the development of diverging thinking. The curricula is focused on the ability to work in teams, the willingness to seek and accept criticism, and the development of critical thinking.
- Teaching focus on evaluating the reliability and importance of knowledge
- Methodology supports active learning: problem based learning (mentioned by all countries), project based learning (3 countries), cooperative learning (2 countries), integration of special needs and individual learning habits (2 countries), extending the learning environment towards social factors such as museums, laboratories, medical centers (mentioned by Spain)
- Tools that foster active participation: computers, media technology, data networks, interactive board.