STEM PARTS OF THE NEW FINNISH NATIONAL CORE CURRICULUM *NOVEMBER 2019*

In April 2017, Finnish government decided to launch a reform of the upper secondary school education. Part of the reform is the new national core curriculum, published in November 2019, that will be implemented starting from August 2021.

The aim of the reform is to raise the educational level in Finland, to increase the attractiveness of upper secondary education and to promote the well-being of high school students.

Scientix supported the translation of the STEM related parts of the new curriculum, providing an insight into the goals, general objectives and core contents of the following subjects: mathematics, biology, geography, physics and chemistry.

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1. MATHEMATICS

1.1. The goal of the subject

The study of mathematics provides students with the ability to understand, apply, communicate and evaluate mathematical information. Students learn to understand the significance of mathematics for modern cultures and recognise its necessity for different fields such as technology, medical science, economics, social sciences, natural sciences and the arts. The purpose of the instruction in mathematics is to introduce students to the basic concepts, ideas and structures of mathematics and to encourage students to use the language of mathematics in spoken, written and other forms. Instruction in mathematics develops students' skills in calculation, creative thinking, modelling phenomena, making predictions and problem-solving.

Through the study of mathematics, students learn to utilise computer software and digital information sources in learning, research and problem-solving. Students also learn to evaluate the usefulness of information technology tools and the limitations for their use.

1.2. Transversal competence in the subject

Instruction in mathematics examines the connections between everyday life and mathematics; makes use of opportunities to strengthen students' interest, self-belief and information-seeking processes; and encourages students to experiment and work with perseverance. Students apply the skills they learn in mathematics to the setting of their own goals and to decision-making. Students reflect on how mathematical skills can be employed to solve problems related to sustainable development and humankind. This reinforces students' **social competence**, **ethics and environmental competence** as well as their **welfare competence.**

Instruction is based on the idea of choosing topics, phenomena and related problems that students are interested in and that can be investigated with mathematics. Diverse methods are employed in teaching, with students working both independently and together with others. This strengthens, among other things, their **interaction competence**. Teaching methods are selected together with students. Teaching situations are arranged so that they inspire students, based on their own observations, to raise questions, make assumptions and draw and justify conclusions.

The study of mathematics supports the transversal objectives for the **global and cultural competence** and for the **multidisciplinary and creative competence**. Students learn to appreciate the significance of mathematics for different cultures and in the development of history, and to understand its nature as a universal language. Students learn to understand the meanings of mathematical concepts and to recognise how they are connected to larger entities both in mathematics and in other subjects. Students are encouraged to use mathematical language and notation as well as pictures, drawings and tools that support reflective thinking. Instruction supports students' skills in moving between different representations of mathematical information when modelling phenomena, understanding and solving problems and discussing results.

1.3. The general objectives for the instruction in mathematics

The general objectives for the instruction in mathematics are that students:

- have positive learning experiences, become accustomed to working with perseverance and learn to trust their own mathematical abilities, skills and thinking
- recognise mathematics both as a unique, independent discipline and as a useful tool when modelling, controlling and predicting social, economic or natural phenomena
- build a mathematical foundation for their further studies
- learn to process data in a mathematical way and become accustomed to making assumptions, investigating their correctness, constructing arguments and evaluating their soundness and the extent to which the results can be generalised
- have the ability to follow a mathematical presentation, read a mathematical text, discuss mathematics, substantiate arguments and evaluate information provided in different forms
- learn to model practical problem situations and employ different response strategies
- become more confident in using experimental and investigative actions, finding solutions and clearly presenting those
- can use appropriate mathematical methods, software and information sources, and understand that a solution produced by software is not enough on its own to prove, substantiate or justify an argument.

1.5. Assessment

A diverse assessment framework and encouraging feedback support the development of students' mathematical thinking and self-confidence and maintain and strengthen their motivation to study. Assessment helps students develop mathematical competence and their skills in working with perseverance. It also guides students towards improving their presentation of mathematical solutions, supports them in the concept creation process, and helps them assess their own work. Successful feedback helps students to recognise their own strengths and to identify, which skills and knowledge require further development and how to develop them.

In the assessment framework, attention is focused on numeracy, selection of methods, mathematical thinking and problem-solving skills, justification and analysis of conclusions, and selection and use of software.

1.6. Moving between syllabuses

If a student moves from the advanced mathematical syllabus to the basic mathematical syllabus, any completed studies are accredited as follows:

Module in the advanced syllabus	Module in the basic syllabus
MAA2	MAB2
MAA3	MAB3
MAA6	MAB8
MAA8	MAB5
MAA9	MAB7

Other advanced syllabus studies, successfully completed or partially completed at the time the student moves from one syllabus to another, that count as extra credits from modules can consist of other optional or thematic studies in the basic syllabus, as determined in the local curriculum.

When a student moves from the advanced syllabus to the basic syllabus, the student shall be provided an opportunity for additional competence demonstrations in order to determine their competence level, if they so wish.

When a student moves from the basic syllabus to the advanced syllabus, the student may be required to complete additional studies, in which case the grade will also be reassessed. When moving between syllabuses, any credits missing in the modules shall be completed as determined in the local curriculum.

The student can also study modules belonging to the other syllabus without moving from one syllabus to another. In this case, the relevant modules can be counted towards the other optional or thematic studies in the student's actual syllabus as determined in the local curriculum.

1.7. Common study module in mathematics

Compulsory studies

MAY1 Numbers and equations (2 credits)

Objectives

- The objective for the module is that students:
- revise the principles of percentage calculation
- can employ proportionality in problem-solving
- deepen their competence in calculating with fractions
- revise the rules for power calculations
- strengthen their understanding of the concept of a function

- understand the principles of solving equations and pairs of equations
- learn to use software in drawing a function graph, making observations and solving equations.

Core contents

- sets of numbers and basic calculations
- opposite number, reciprocal number and absolute value
- percentage calculation
- rules for power calculations (where exponent is an integer)
- direct and inverse proportionality
- functions, drawing a function graph and interpreting a function graph
- solving a first order equation
- pair of equations
- square root and cubic root
- power function and power equation (second and third order).

1.8. Advanced syllabus in mathematics

1.8.1. Compulsory studies

MAA2 Functions and equations 1 (3 credits)

Objectives

The objective for the module is that students:

- explore the mathematical modelling of phenomena with the help of polynomial, rational and root functions; know the properties of polynomial, rational and root functions; can solve equations relating to these; and understand the connection between the null points in the polynomial functions and polynomial factors
- can solve simple polynomial inequalities
- can use software in mathematical modelling; in examining polynomial, rational and root functions; and in solving polynomial, rational and root equations and polynomial inequalities in mathematical applications.

Core contents

- polynomial functions and polynomial equations, polynomial inequalities
- formulas for solving second order equation
- polynomial products and binomial formulas (square of sum, product of sum and difference)
- polynomial factors
- power functions and power equations (where exponent is a positive integer)
- rational functions and rational equations
- root functions and root equations.

MAA3 Geometry (2 credits)

Objectives

- The objective for the module is that students:
- learn to illustrate and describe information about space and form in both two dimensions (2D) and three dimensions (3D)
- can apply similarity, Pythagoras's theorem and trigonometry of right-angled and oblique triangles
- learn to formulate, justify and use theorems containing geometrical information
- can use software when investigating shapes and solids and related geometry.

Core contents

- similarity of shapes and solids
- law of sines and cosines
- calculating lengths, angles and areas related to polygons
- geometry of circle, its parts and the related lines
- calculating lengths, areas and volumes related to right cylinder, right cone and sphere.

MAA4 Analytical geometry and vectors (3 credits)

Objectives

- The objective for the module is that students:
- understand, how analytical geometry creates relationships between geometrical and algebraic concepts
- understand the geometrical meaning of an equation
- can solve absolute value equations of the form | f(*x*) | = *a* or | f(*x*) | = | g(*x*) |
- understand the concept of a vector and learn the basics of vector calculation
- can investigate points, distances and angles of a two-dimensional coordinate system using vectors
- can solve plane geometry problems using vectors
- can use software in examining curves and vectors and in applications related to them.

Core contents

- equations of curve
- equations of lines, circles and parabolas
- group of equations
- parallelism and orthogonality of lines
- absolute value equation
- distance from a point to a line
- basic properties of vectors
- addition and subtraction of vectors in the plane and multiplication of vectors in the plane by a real number
- dot product of vectors in the plane, angle between vectors in the plane.

MAA5 Functions and equations 2 (2 credits)

Objectives

The objective for the module is that students:

- explore the mathematical modelling of phenomena with the help of sine and cosine functions and exponential and logarithmic functions

- examine sine and cosine functions with the help of symmetries of a unit circle
- can solve trigonometric equations of the type
  $\sin f(x) = a$ or $\sin f(x) = \sin g(x)$
- can apply the relationship between sine and cosine functions $\sin^2 x + \cos^2 x = 1$
- know the properties of exponential and logarithmic functions and can solve equations related to them
- can use software in examining functions and solving equations and in mathematical applications.

Core contents

- directed angle and radian
- unit circle
- sine and cosine functions and their symmetry and periodicity
- solving sine and cosine equations
- fractional exponent and its relationship with a root
- exponential functions and exponential equations
- logarithms and logarithm laws
- logarithmic functions and logarithmic equations.

MAA6 Derivative (3 credits)

Objectives

- The objective for the module is that students:
- explore with the help of a derivative how mathematical models for phenomena behave
- obtain an illustrative understanding of the limit value and continuity of function
- understand the interpretation of derivative as a rate of change of function
- can determine derivatives of simple functions
- can differentiate composite functions
- can examine the course of functions with the help of derivatives and how to find their extrema on a closed interval

- can use software in investigating the limit value, continuity and derivative in mathematical applications.

Core contents

- limit value, continuity and derivative of function
- derivatives of polynomial, rational and root functions
- derivatives of sine and cosine functions and of exponential and logarithmic functions
- derivative of the product and quotient of functions
- composite function and its differentiation
- examining the course of a function and determining the extrema.

MAA7 Integral calculus (2 credits)

Objectives

- The objective for the module is that students:
- understand the concept of an integral function and learn to determine integral functions of simple functions
- understand the concept of a definite integral and its relationship to area and explore the numerical method for determining a definite integral
- can determine areas and volumes with the help of a definite integral
- learn the applications of integral calculus
- can use software for examining the properties of a function, determining an integral function and calculating a definite integral in mathematical applications as well as for numerical integration.

Core contents

- integral function and the integration of the most important elementary functions
- definite integral
- rectangle rule
- calculating area and volume.

MAA8 Statistics and probability (2 credits)

Objectives

- The objective for the module is that students:
- learn to illustrate discrete statistical distributions and to determine and interpret statistics
- can illustrate the common distribution of two variables and determine the correlation coefficient and regression curve
- learn combinatorial methods
- learn the concept of probability and calculation rules
- understand the concept of discrete probability distribution and learn to determine the expected value of a distribution and interpret it
- can use software in retrieving, processing and examining digital data and for presenting statistical data
- can utilise software in illustrating distributions, determining statistics and calculating probabilities.

Core contents

- central tendency and standard deviation
- correlation and linear regression
- odds and statistical probability
- permutations and combinations
- probability calculation rules
- binomial distribution
- discrete probability distribution
- expected value of a discrete distribution.

MAA9 Mathematical economics (1 credit)

Objectives

The objective for the module is that students:

- learn to apply their mathematical skills to the sufficiency of resources, budgetary planning, entrepreneurship and calculation of profitability

- apply the formulas of sequences to mathematical problems related to economy
- learn to adapt mathematical models to economic situations and understand their limits
- can utilise software in making calculations and in mathematical applications.

Core contents

- arithmetic and geometric sequence and their sums
- interest calculations: compound interest, present value and discounting
- savings and loans
- mathematical models which apply to economic situations and which utilise sequences and sums.

1.8.2. National optional studies

MAA10 3D geometry (2 credits)

Objectives

The objective for the module is that students:

- deepen their knowledge of vector calculation and learn to use vectors in three-dimensional space
- learn to examine points, lines and planes of an *xyz*-coordinate system with the help of vectors
- strengthen their competence in solid geometry in connection with the applications of extrema
- explore the function of two variables
- can use software in illustrating vectors, lines, planes and surfaces and in vector calculation.

Core contents

- vector format in a three-dimensional coordinate system
- dot and cross product
- dot, line and plane in space
- angle in space
- applications of differential and integral calculus with one variable in solid geometry

- function with two variables and surface in space.

MAA11 Algorithm and number theory (2 credits)

Objectives

The objective for the module is that students:

- know what an algorithm is and learn to examine how algorithms function
- create algorithms related to simple mathematical problems
- learn to program simple algorithms
- study the concepts of logic
- master the basic concepts of the number theory and study the properties of prime numbers
- can examine integer divisibility
- can use software in programming and investigating numbers.

Core contents

- basic concepts in algorithmic thinking: sequencing, selection and repetition
- flowchart
- the programming of simple mathematical algorithms, sorting algorithms or algorithms for solving equations numerically
- logical operators and truth values
- the divisibility of integers, division equation and congruence
- Euclidean algorithm
- the fundamental theorem of arithmetic.

MAA12 Analysis and continuous distribution (2 credits)

Objectives

The objective for the module is that students:

- deepen their understanding of the basic concepts of analysis
- can formulate and examine inverse functions of strictly monotonic functions

- complement their skills in integral calculus
- explore the concept of continuous probability distribution and learn to use normal distribution
- can use software when examining the properties of a function and calculating improper integrals in mathematical applications.

Core contents

- piecewise-defined function
- examining continuity and differentiability of a function
- general properties of continuous and differentiable functions
- inverse function
- limits of functions in infinity
- improper integrals
- continuous distributions, normal distribution and standardisation.

1.9. Basic syllabus in mathematics

1.9.1. Compulsory studies

MAB2 Expressions and equations (2 credits)

Objectives

The objective for the module is that students:

- learn to use mathematics in solving problems and learn to trust their own mathematical skills
- learn to formulate expressions and equations for given problems, to solve equations and to interpret the result obtained
- can apply sequences and the sums formed from them to solving mathematical problems
- can use software in mathematical modelling, examining polynomial function, and in mathematical applications related to polynomial equations and polynomial functions.

Core contents

- formulating problems as equations

- solving equations
- interpreting and assessing solutions
- solving a second order polynomial function and a second order equation
- arithmetic sequence and sum
- geometric sequence and sum.

MAB3 Geometry (2 credits)

Objectives

The objective for the module is that students:

- learn to make observations and deductions about the geometric properties of shapes and solids
- strengthen their skills in drawing planar shapes and pictures of three-dimensional solids
- can solve practical problems using geometry
- can use software in examining shapes and solids and in mathematical applications related to geometry.

Core contents

- similarity of shapes
- trigonometry of a right-angled triangle
- Pythagorean theorem and inverse of Pythagorean theorem
- determining area and volume of shapes and solids
- applying geometric methods in a coordinate system.

MAB4 Mathematical models (2 credits)

Objectives

The objective for the module is that students:

- recognise regularities and dependencies in real life events and represent them with mathematical models
- evaluate models for linear and exponential growth with, among others, a spreadsheet program and make predictions based on the models

- become used to evaluating the goodness of fit and the usability of models
- can use software in examining the properties of polynomial and exponential functions and solving polynomial and exponential equations in mathematical applications.

Core contents

- applying linear and exponential models
- solving an exponential equation
- predictions and goodness of fit of a model.

MAB5 Statistics and probability (2 credits)

Objectives

- The objective for the module is that students:
- learn to process, illustrate and interpret statistical data
- study the principles of probability calculation and models that represent probability calculation
- can use software in retrieving, processing and examining digital data; in determining the statistics for a data set; and in probability calculation.

Core contents

- representing a data set and determining the statistics
- the concepts of regression and correlation
- observations and outlier
- making predictions
- the concept of probability
- addition and multiplication rule
- combinations and rule of product
- models for probability calculation.

MAB6 Elements of mathematical economics (1 credit)

Objectives

The objective for the module is that students:

- master the basic concepts and skills in mathematical economics
- deepen their skills in percentage calculation
- learn to describe the development of various issues in economics
- can use information sources and software for making calculations in mathematical applications.

Core contents

- proportional share, comparison, change calculation
- index
- the concept of interest, simple interest
- taxation
- currencies.

MAB7 Mathematical economics (1 credit)

Objectives

- The objective for the module is that students:
- learn to apply their mathematical skills to the sufficiency of resources, budgetary planning, entrepreneurship and calculation of profitability
- apply the formulas of sequences to mathematical problems related to economy
- learn to adapt mathematical models to economic situations and understand their limits
- can utilise software in making calculations and in mathematical applications.

Core contents

- arithmetic and geometric sequence and their sums
- interest calculations: compound interest, present value and discounting
- savings and loans

- mathematical models which apply to economic situations and which utilise sequences and sums.

1.9.2. National optional studies

MAB8 Mathematical analysis (2 credits)

Objectives

The objective for the module is that students:

- explore the rate of change of a function with graphical and numerical methods
- understand the interpretation of derivative as a rate of change of function
- can examine the course of a polynomial function using derivatives
- can determine the greatest and lowest value of a polynomial function in mathematical applications
- can use software in examining the course of a function and in determining the derivative of a function and extrema on a closed interval in mathematical applications.

Core contents

- graphical and numerical methods
- derivative of a polynomial function
- examining the sign and the course of a polynomial function
- determining the greatest and lowest value of a polynomial function on a closed interval
- determining the rate of change of a function with software.

MAB9 Statistical and probability distributions (2 credits)

Objectives

The objective for the module is that students:

- explore normal distribution as a mathematical model
- explore binomial distribution as a mathematical model
- strengthen and broaden their skills in processing and examining statistics with the help of software
- can calculate statistics and probabilities based on statistical distributions and can determine these with software

- understand the concepts of confidence interval and margin of error and can determine these with software.

Core contents

- the concepts of normal distribution and standardisation of distribution (expected value and standard deviation)
- repeated trial
- binomial distribution
- the concepts of confidence interval and margin of error.

2. BIOLOGY

2.1. The goal of the subject

Biology is a natural science that studies life-related phenomena from molecular and cellular level to the biosphere. The purpose of the instruction in biology is to develop interest in the life and environmental sciences and to support students in developing their natural-scientific thinking. The instruction reinforces students' knowledge about the significance of biology for building a scientific world view. Scientific world view is based on scientific research and thus helps students to view the world in a knowledge-based way. The instruction in biology helps students to understand the structure, function and interrelationships of the natural world and the significance of evolution for the development of living organisms.

Biology, as a subject, gives students skills for their everyday life, working life and further studies. Through the study of biology, students obtain a picture of the life sciences as rapidly developing disciplines, the applications of which are utilised in many different ways in fields such as medical science, industry, agriculture and forestry. The instruction in biology helps students understand the opportunities offered by life sciences to advance the welfare of humankind, other living organisms and living environments.

Information gathering based on observations and experiments, research-based practises, and working methods that are both active and interactive are characteristic features of the instruction in biology. Teaching involves laboratory work and also working in digital environments and learning environments outside school. As studies progress, students' skills in empirical work become more versatile and in-depth. There is versatile collaboration with other subjects in the instruction in biology. Phenomena, which are included in the instruction in biology, will be examined in other subjects, especially in geography, chemistry, physics, psychology and health education in a way that is typical for each subject.

2.2. Transversal competence in the subject

The instruction in biology is based on the understanding of biodiversity and its development. The building of a sustainable future is a central theme in the instruction. The objectives for transversal competence are realised when the objectives for biology are achieved.

The instruction in biology reinforces students' **welfare competence** in a natural way. The instruction increases students' appreciation of how significant a biodiverse, clean and healthy environment is to the holistic well-being of people. Biology emphasises the differences and diversity of individuals, and explains the biological background for this, which gives students tools to understand diversity. Students receive guidance in setting their own goals, and are supported and encouraged at different stages of the learning process, which builds up their self-knowledge and perseverance.

In biology, students improve their **interaction competence** by learning to present arguments and evaluate their own and other people's views with the help of biological information. Teaching is carried out in different learning environments and by using diverse working methods, which develops students' social and interaction skills.

The instruction in biology steers students towards natural-scientific thinking, information gathering and critical analysis of the information, which supports their **multidisciplinary and creative competence**. The instruction introduces students to the language and terminology of, and the ways of developing knowledge in, biology and associated disciplines. Through the instruction in biology, students learn a research-based approach and a multidisciplinary and creative way of working in various learning environments.

Regarding students' **social competence**, the instruction in biology gives them the skills to work in fields that are important to society, such as healthcare, environmental fields, agriculture and forestry. Life sciences are rapidly developing international disciplines, and their applications are utilised in society at a local, national and international level. The instruction in biology gives students a knowledge base that helps them take a position on many topical social issues and helps them consume media critically. Students are steered towards a sustainable way of life and towards taking a global responsibility as active members of society, which enforces students' **global and cultural competence**.

The instruction in biology develops students' **environmental competence** and willingness to preserve biodiversity. It emphasises the understanding of the uniqueness and intrinsic value of nature. The instruction deals with the opportunities provided by applications and ecosystem services in relation to a sustainable future. The instruction helps students make sustainable choices in their everyday lives and apply biological knowledge in deliberations that require **ethics**.

2.3. The general objectives for the instruction in biology

The instruction in biology fosters students' ability to observe phenomena from a life sciences' point of view, and strengthen and deepen their biological knowledge, skills and competence in a comprehensive way. The objectives refer to a biological approach; biological phenomena and processes; and biological skills and their application. The general objectives for the instruction are described in detail below.

Biological approach

The objective is that students:

- can use the key concepts in biology accurately and in correct contexts
- can illustrate biological phenomena by giving examples of species
- understand that biological knowledge is based on research, and that important biological research is carried out in Finland
- understand the significance of biological knowledge and the applications based on this knowledge for innovations and for solving different problems
- gain experiences that increase their interest in biology and the study of biology.

Biological phenomena and processes

The objective is that students:

- know the basic structures and functions of organisms
- understand biological cause-effect relations, from the molecular level to the biosphere
- understand the importance of evolution
- know applications based on biological information.

Biological skills and their application

The objective is that students:

- plan and carry out, independently or in groups, experimental work in various learning environments such as in the field, in laboratories and in virtual environments
- have opportunities to become familiar with biological applications through visits or through collaboration with higher education institutions or workplaces at a local or international level
- use and critically evaluate biological information sources, and express and justify different views in a way that is characteristic for biology
- understand the importance of maintaining the biodiversity of livings organisms, recognise the necessity of sustainable development, and find the initiative to act for positive solutions.

2.4. Assessment

Assessment in biology evaluates how well the objectives for the subject have been achieved, with the emphasis on the objectives and contents of each module. Assessment and feedback given during the learning process help students become aware of their own ways of working and develop their own competences. Grades are awarded on the basis of a varied demonstration of competences and of the observations on students' conceptual and methodological competence.

The assessment framework focuses on students' skills and knowledge, such as on their command of the basic concepts of biology, and on their reflection, justification and research skills. Assessment takes into account students' ability to understand, apply, analyse, evaluate and present biological information in different situations. Assessment evaluates students' understanding of the fundamental principles of the natural sciences and the cause-effect relations, their grasp of the importance of interrelationships, and their ability to perceive the whole. Assessment also takes into account students' ability to critically evaluate information.

Students can also demonstrate the competence that is being assessed through empirical work in the field or in laboratories, or with presentations, essays and other output.

2.4.1. Compulsory studies

BI1 Life and evolution (2 credits)

This module introduces students to the conditions for life and to the properties that all organisms have. The central theme in the module is evolution and the appreciation of its importance. Students are introduced to the biological way for collecting and describing information and to biology as a part of the natural sciences.

Objectives

The objective for the module is that students:

- can explain the properties and basic conditions for life and recognise them in examples
- know the basic structure and function of cells to such an extent that they understand how evolution works and how ecosystems work
- can explain the mechanisms of genetic diversity, natural selection and speciation, and can explain their significance for evolution
- can classify the structure of current living organisms
- understand and can explain how biological information is produced.

Core contents

Biology as a science

- properties and hierarchical levels of life
- biological disciplines and research methods
- biological observations, research questions and the developing of hypotheses

Evolution

- creation and development of cells
- sexual and asexual reproduction
- variation and its genetic reasons
- natural selection
- speciation
- plant and animal evolution and key adaptations
- human evolution

- the study of evolution

Living organisms

- the principles of classification
- family tree of living organisms and key taxa

BI2 Basics of ecology (1 credit)

This module explores the basics of ecology and the diversity of life.

Objectives

The objective for the module is that students:

- can explain and evaluate the effect of abiotic and biotic environmental factors on the adaptation and the distribution of organisms
- can explain the structure and function of populations, communities and ecosystems and describe them using examples
- can describe biodiversity and justify its importance.

Core contents

Basics of ecology

- the structure and dynamism of ecosystems
- cycle of carbon, nitrogen and phosphorus and the flow of energy in an ecosystem
- the properties of populations
- adaptation, ecological niches and distribution
- relationships between species

Biodiversity

- genetic diversity, species diversity, ecosystem diversity
- the significance of diversity.

BI3 Human impact on ecosystem (1 credit)

The central themes of this module are the environmental problems in Finland and elsewhere in the world. Students are introduced to the ecological research and how it can be employed in protecting ecosystems and diversity.

Objectives

The objective for the module is that students:

- know methods for examining and following the state of the environment and for identifying environmental problems
- can compare, analyse and evaluate the impacts of human activity on ecosystems
- can present, with justifications, solutions to environmental problems and recognise the positive trends in the state of the environment
- can evaluate and justify their own actions in relation to the ecological sustainability
- can collect, analyse, interpret and present ecological research data.

Core contents

Changes in ecosystems caused by human activity and solutions to environmental problems

- the impact of the climate change on ecosystems
- acidification
- eutrophication
- impacts of contaminants on the food chain
- impacts of humans on biodiversity

Towards a sustainable future

- the significance of ecosystem services and the ecological sustainability
- actions for encouraging a sustainable way of life and influencing the state of the environment.

2.4.2. National optional studies

BI4 Cell and heredity (2 credits)

This module explores the structure of a eukaryotic cell, the control of cell activities, cell reproduction and the basics of heredity. Cell functions are illustrated with experimental work.

Objectives

The objective for the module is that students:

- can name the basic structures of a cell
- can explain the main functions of cells

- master the basic mechanisms of heredity and can apply them with the help of examples
- can examine different types of cells using a microscope and interpret the microscopic structures of cells
- can carry out a small experimental work.

Core contents

The structure and function of a eukaryotic cell

- cell as an object of research
- biomolecules
- animal, plant and fungal cell
- gene expression and its regulation
- photosynthesis
- cell respiration, fermentation reactions

Cell reproduction

- mitosis and cell division
- meiosis and the formation of gametes

Basics of heredity

- new alleles created by gene mutations
- the Mendelian inheritance
- the Codominant inheritance
- the Polygenic inheritance
- sex-linked inheritance
- determining the type of inheritance on the basis of a family tree.

BI5 Human biology (2 credits)

This module introduces students to the human anatomy and physiology. The focus is on the functions of the human body and on reproduction. The module explores the ability of a human organism to adapt to changes and to defend itself against external threats.

Objectives

The objective for the module is that students:

- can name and identify the structures of the most important organs and organisms, and explain the principles of how they work
- understand homeostasis, and can give examples of factors that influence it
- can describe body's communication systems and explain how different parts communicate with each other
- can explain body's ability to sense the environment and react to changes
- can explain and compare body's different defence mechanisms against microbes
- can explain and justify the main stages in reproduction from fertilisation to birth
- can carry out small-scale experimental work that measures the function of a human body and present the outcome.

Core contents

Cell, tissue, organ

- stem cell specialisation and cancer cells
- the generation of organs from different types of tissue

Body regulation

- the structure and function of the nervous system
- endocrine glands and hormones

Metabolism

- the digestive system
- the circulatory system
- the respiratory system

- secretion of metabolic waste

Movement

- the musculoskeletal system

Body's adaptation to the environment

- skin and thermoregulation
- senses
- the defence system

Reproduction

- sexual organs and gender development
- fertilisation, pregnancy and birth.

BI6 Biotechnology and its applications (2 credits)

The purpose of the module is that students understand the significance of biological research for developing applications for medicine, industry, food production and for the sustainable use of natural resources. The focus is on various applications of gene technology and microbiology. The module introduces the latest biotechnology applications in this rapidly developing field.

Objectives

The objective for the module is that students:

- know the structures of different microbes and understand their basic functions
- can give examples of how microbes can be utilised in biotechnology
- deepen their knowledge of nucleic acids and their properties, and know how they can be utilised in gene technology
- can explain, with the help of examples, the main biotechnological applications and innovations, and justify their importance for breeding, medical sciences, industry and environmental protection
- can identify and evaluate the opportunities and risks of biotechnology and give well-founded opinions on them

- can plan and carry out experimental work related to the application of biology.

Core contents

Microbes

- the classification of microbes
- the structure, variation and antibiotic resistance of bacteria
- the structure and reproduction of viruses
- the utilisation of microbes in biotechnology

DNA engineering and examination using gene technology

- the differences in the genome and the function of the genes in eukaryotic and prokaryotic cells
- the copying, cutting up and separating of the fragments of DNA
- determining the information contained in DNA
- gene transfer and modification techniques

Main applications of biotechnology and their importance

- traditional and gene technology-based plant and animal breeding
- medical sciences
- genomic information and its utilisation
- identification of individuals and species on the basis of DNA information
- environmental protection
- industry.

3. GEOGRAPHY

3.1. The goal of the subject

Geography examines natural, human and social phenomena and their interactions. The purpose of the instruction in geography is to widen students' geographical world view; to develop their ability to understand global, regional and local phenomena and their changes over time; and regional problems and their possible solutions.

Through the instruction in geography, students learn to notice factors that effect changes in the world; to form well-founded views; to take a stance on the changes in their own environment, in the neighbouring areas and in the whole world; and to take an active role in improving human welfare and preserving the natural world. The instruction gives students opportunities to practise their participation and influencing skills and supports students in building a sustainable future. Through the instruction in geography, students become aware of the interaction between nature and human activity, and learn to view the world as a changing and culturally diverse living environment.

The instruction in geography integrates the topics of natural sciences with those of human and social sciences. The instruction gives students the ability to scrutinise environmental and human rights questions, and supports their development to educated and responsible citizens.

Teaching is based on young people's lifeworld and students' everyday experiences and observations. Teaching utilises different learning environments in a variety of ways. An investigative approach and the use of geomedia help students develop their geographical thinking and understand the changes taking place in their everyday environment at a local, regional and global level. Geomedia refers to the ways geographical information is collected and presented, such as maps, geospatial information, diagrams, pictures, videos, written sources, media and verbal presentations. The versatile use of geomedia supports students in the collection, analysis, interpretation and visual presentation of geographical information. Current news is discussed in the instruction of geography, which helps students form their own world view and develop their critical thinking. It also helps them understand the changes taking place in their neighbourhood and elsewhere in the world.

3.2. Transversal competence in the subject

The objectives for transversal competence are realised when the objectives for geography are achieved.

The teaching in geography supports the development of students' **welfare and interaction competence**. The instruction in geography typically employs student-centred and interactive working methods in varying learning environments. The instruction in geography emphasises social and collaboration skills as well as the responsibility for one's own and other people's working. Students receive guidance in setting their own goals and are supported and encouraged at different stages of the learning process, which builds up their self-knowledge and perseverance.

Through the instruction in geography, students develop a research-based approach and a multidisciplinary and creative way of working. The instruction introduces students to the

language and terminology of, and the ways to develop knowledge in, geography and associated disciplines. Geomedia skills strengthen students' multiliteracy skills. The instruction in geography inspires students to think and to collect and analyse information in a way that is characteristic of natural sciences and of human and social sciences.

The instruction in geography gives students a knowledge base that helps them take a position on many topical social issues and helps them consume media critically. The instruction increases students' understanding of the importance of sustainable development as a starting point for regional planning and gives them the skills for participatory planning. Students are steered towards a sustainable future and the understanding of the global responsibility as active members of society, which reinforces their **social competence**.

The study of geography strengthens students' **ethical and environmental competence** in a comprehensive way. The instruction increases students' understanding of cultural diversity and the importance of the natural environment. Through the instruction in geography, students learn the necessity of a sustainable way of life. The instruction helps students apply the geographical skills and knowledge in their everyday lives, in ethical considerations and in making sustainable consumer choices.

The instruction in geography deepens students' understanding of the importance of human rights, the diversity of society and the formation of a regional identity, thereby supporting the development of students' **global and cultural competence**. The examination of current worldwide phenomena and their interrelationships is a characteristic feature of geography. Geography supports the building of students' internationalism skills, their skills for the future and helps them grow into educated and broad-minded citizens.

3.3. The general objectives for the instruction in geography

The instruction in geography strengthens students' geographical thinking, deepens their understanding of phenomena and processes, and develops their management and application of versatile skills. The general objectives for the instruction are described in detail below.

Geographical thinking

The objective is that students:

- gain experiences which deepen their interest in geography and the way geography views and examines the world
- know the properties of geography as a scientific discipline, and understand why geographical competence is needed in everyday life, studying and working life
- can use geographical concepts accurately and express well-founded views in correct contexts and in a way that is characteristic of geography
- develop their command of the world map and toponomy
- can study the world from different starting points, such as from the individual, societal and environmental perspectives

- understand the necessity of a sustainable lifestyle and the importance of a circular economy that saves natural resources.

Geographical phenomena and processes

The objective is that students:

- understand phenomena and processes of physical geography
- understand phenomena and processes of human geography
- understand the interaction between the phenomena and processes of physical and human geography.

Geographical skills and their application

The objective is that students:

- can observe everyday environments and interpret the landscape
- can compare and analyse regional phenomena, structures and interrelationships of nature and human actions and their changes at different regional levels
- can observe, describe and analyse human welfare locally, regionally and globally
- can reflect on and evaluate possible solutions to environmental changes and changes caused by human actions
- understand, apply and analyse geographical information and utilise geomedia in a comprehensive way in collecting, evaluating and presenting information
- follow current world events and can critically evaluate factors affecting these and the possible consequences
- know ways to develop regions, participate and influence
- gain the ability to act as active citizens of the world who speak out and promote a sustainable future.

3.4. Assessment

The attainment of the general objectives for geography is assessed through the objectives of each module and the core contents. Assessment and feedback given during the learning process help students become aware of their own ways of working and develop their own competences. Grades are awarded on the basis of a varied demonstration of competences and observations of students' conceptual and methodological skills and knowledge.

The assessment framework in geography focuses on geographical thinking; the understanding of geographical phenomena and processes; and the knowledge and application of geographical skills. Students can demonstrate their geographical thinking and knowledge

using many different methods. Assessment takes into account students' ability to understand, apply, analyse, evaluate, illustrate and present geographical information in different situations. The central skills assessed in geography are map reading and interpreting skills, graphical presentation skills and other geomedia skills. Students can also demonstrate the competence that is being assessed with field work and with presentations, essays and other output.

3.4.1. Compulsory studies

GE1 The world in change (2 credits)

This module helps students observe the changing world and its regional phenomena through the changes of the environment and humankind. During the module, students follow current news topics around the world and learn to see worldwide changes in relation to nature, environment and humankind. The module also deals with the positive developments taking place in different parts of the world and the opportunities for anticipating and containing changes as well as preparing for and adapting to changes.

Objectives

The objective for the module is that students:

- develop their geographical world view and learn to use toponomy with ease in appropriate contexts
- can analyse the reasons for environmental changes and evaluate the consequences of environmental changes in different regions
- know methods for containing environmental changes or mitigating their effects in different regions and can explain what kind of solutions help achieve this
- can analyse the causes for changes in humankind and evaluate the consequences of the changes in different regions
- know methods and can evaluate how to influence the changes caused by human activity in different regions
- know the commitments related to sustainable development and can use them as a basis for ethical justification of ideas
- can collect, analyse and present relevant and reliable information about regional questions using geomedia
- can critically evaluate current regional news in different media about environmental changes or changes of humankind.

Core contents

Geography as a scientific discipline

- observing the environment and the world from a geographical perspective

- utilising geography in the working and everyday life
- current regional news

Environmental changes and their solutions

- the mechanisms of climate changes
- reasons for, and consequences of, the current climate change
- drought, desertification, storms and floods
- adaptation to environmental changes and containment of the changes

Changes in humankind

- environmental impacts worldwide caused by the population growth and the increase in wealth
- lack of clean water, hunger
- wealth distribution, poverty
- refugees
- commitments of sustainable development.

3.4.2. National optional studies

GE2 The blue planet (2 credits)

The module deals with the phenomena of physical geography and deepens the knowledge of the structure and function of the atmosphere, the hydrosphere and the lithosphere. The central themes are the processes taking place in nature and the associated cause-effect relations. All themes are dealt with from the regional perspective. With each theme, the associated risks and problems as well as positive developments are also covered.

Objectives

The objective for the module is that students:

- can use the basic concepts of physical geography and toponomy appropriately
- can collect, analyse, interpret, evaluate and present physical geographical information using geomedia

- can explain phenomena arising from planet Earth's shape and movements and give reasons for the effects these phenomena have on natural systems
- can describe and analyse the regional variation in plants, animals and physical geography throughout the world
- can interpret the structure, formation and development of natural landscapes from pictures and maps, and explain by giving reasons how and why natural landscapes change
- can analyse the causes of natural risks and assess the consequences of those natural risks in different regions
- can explain and compare with the help of examples how the consequences of natural risks can be anticipated and the effects mitigated in different regions
- understand the importance of physical geography information in society and in people's everyday life.

Core contents

The way of thinking in physical geography

- formulating questions of physical geography and collecting, analysing, evaluating and presenting physical geography information
- information sources and research methods in physical geography

Earth's planetary movements and phenomena caused by them

Atmosphere and hydrosphere

- the structure of the atmosphere and winds, changes in the ozone layer
- the water cycle, rain and seawater movements (e.g. ENSO and NAO)
- weather, forecasting weather
- climate regions

Lithosphere

- the structure of the Earth, the rock cycle
- endogenous and exogenous events shaping the surface of the Earth
- endogenous and exogenous phenomena as risks, main risk areas, anticipation and preparation for the risks

Soils and vegetation regions

GE3 The common world (2 credits)

The module deals with phenomena of human geography and deepens the knowledge of the regional characteristics of human activity and interaction. Central themes are the evaluation of the opportunities provided by the natural resources and the environment from the aspect of human activity, the accountability of human activity and the welfare of the environment. All themes are dealt with from the regional perspective. With each theme, the associated risks and problems as well as positive developments are also covered.

Objectives

The objective for the module is that students:

- can use the concepts of human geography and toponomy appropriately
- identify cultural traits and their differences, value their diversity and take human rights into account in their actions
- can collect, analyse, evaluate and present human geography information using geomedia
- can describe and analyse the regional traits of human activity and the interdependencies between humans and nature at different regional levels
- can analyse the way that the opportunities offered by the natural resources and the environment influence human activity and compare different regions
- can analyse, with the help of examples, the causes of environmental risks and risks to the humankind, evaluate their consequences and identify ways to contain the consequences of the risks or mitigate their effects in different regions
- understand the importance of the human geography information in society, people's everyday life and their own actions.

Core contents

The way of thinking in human geography

- formulating questions of human geography and collecting, analysing, evaluating and presenting human geography information
- information sources and research methods in human geography
- experiencing places and mind maps

Population, human settlement and cultures

- population structure and demographic changes

- location of settlements, migration
- the diversity of cultures, the regional identity and the upholding of human rights, such as the status of indigenous people

Towns and urbanisation

- land use and the built environment
- changes in urban environments and ecocities

Regional properties of production and the sustainable use of natural resources

- agriculture, forestry and fishery
- minerals, energy sources
- industry
- the circular economy

Travel, services and interaction

- accessibility, transport networks and tourism
- globalisation
- regional spread of innovations

GE4 Geomedia – research, participate and influence (2 credits)

The module trains students to apply the geographical knowledge and skills obtained in previous modules to writing an essay or carrying out a project on participation and influencing. The central themes in the module are regional planning, the principles of participatory planning and the use of geomedia in research and influencing.

Objectives

The objective for the module is that students:

- can formulate geographical questions and carry out research or a project on participation and influencing, which has a local, regional or global reach
- understand and can explain how geomedia are applied to geographical research, one's own everyday life and different areas of society

- can utilise geographical information system (GIS) applications and know the principles of how they work
- can observe everyday environments; interpret landscape and maps; describe and explain regional phenomena, structures and interrelationships of nature and human activity
- know and can describe the objectives for and different levels of regional planning and the possibilities for citizens to influence the planning and development of their own environment.

Core contents

Geographical research

- the use of geomedia in research: the basics of cartography and geospatial information, pictures, videos, diagrams and tables as well as other sources of regional information
- formulating problems and the collection, processing, analysing, interpreting, evaluating, illustrating and presenting of research data
- interpretation of natural and cultural landscapes with the help of maps, pictures and other geomedia
- the use of geomedia in the everyday and working life and in promoting a sustainable future

Regional planning and the principles of participatory planning

- town and country planning at different regional levels
- ways of participation

Geographical essay or a project on participation and influencing (as chosen by each student)

- The standpoint for the essay or project can be based on regional geography or a phenomenon. Central for the handling of the subject is the regional dimension and the understanding of the interaction of human and nature. The essay or other project is completed independently or in a group.

4. PHYSICS

4.1. The goal of the subject

The instruction in physics supports the development of students' natural-scientific thinking and world view as part of a broad general education. Through the instruction, students learn to understand the significance of physics for everyday life, the environment, society and technology. The instruction introduces students to the language, the terminology and the ways of developing knowledge of the subject and associated disciplines. As students' natural-scientific literacy improves, it helps students critically evaluate various everyday choices and viewpoints in a social debate. The instruction in physics gives students skills to succeed in their further studies in the natural sciences and other fields that apply the natural sciences and skills to apply their competence in physics in the working life. Diverse learning situations and environments encourage opportunities for an egalitarian and equal way of learning.

The instruction in physics develops students' understanding of the concepts of physics and students can understand them at qualitative and quantitative levels. Students' previous experiences, new observations and viewpoints form into a coherent notion of the reality around them through the interaction between students and teachers and using theories in physics.

Instruction in physics is based on the observations made about the environment. Experimentation in its different forms supports the attaining and understanding of concepts, the learning of research skills and the perceiving of the characteristics of the natural sciences. As studies progress, students develop their overall research skills as well as those in relation to the core contents of each module. Experimental work is carried out in accordance with the occupational safety principles.

4.2. Transversal competence in the subject

The instruction in physics steers students towards a way of thinking, information gathering and use, innovation, interaction and evaluation of the reliability and significance of information that is characteristic of the natural sciences. The instruction develops students' **social competence** by giving students the skills to participate in social debates and to influence joint decision-making.

Students' own experimental working develops their work and collaboration skills and their creative and critical thinking, while inspiring students to study physics. Students develop their **interaction competence**, they learn perseverance and they learn to take responsibility for their own work with the help of diverse working methods, such as project learning and working in groups.

The instruction gives a picture of the importance of physics in building a sustainable future: physics is needed in developing new solutions and ensuring environmental and human welfare locally, nationally and internationally. The instruction steers students towards taking responsibility for their own actions and the environment, using their competence in physics to build a sustainable future and evaluating their own choices in relation to the sustainable use of natural resources, the environmental and health impacts, and the methods of energy

production. Thus the instruction in physics supports the **ethics and environmental competence**, the **global and cultural competence** as well as the **welfare competence**.

During the study of physics, students practise writing as well as critically interpreting and analysing different texts. Multiliteracy skills are developed by interpreting and producing, for example, written text, pictures, videos, tables, diagrams and formulas. The study of physics also supports **multidisciplinary and creative competence** through the use of information and communication technology. Information and communication technology is used, for example, for searching for information, collecting experimental observations, processing and interpreting measurement results, composing and presenting work as well as modelling and simulating.

4.3. The general objectives for the instruction in physics

The general objectives for the instruction in physics relate to the significance, values and approaches of physics and to the knowledge of physics and its use. The general objectives for the instruction are described in detail below.

Meaning, values and attitudes

The objective is that students:

- can evaluate the significance of physics for individuals and society
- recognise their competence in physics and can set their own objectives, face their learning challenges and apply learning strategies in physics
- study the application of physics in diverse situations, such as in nature, industries, organisations and scientific communities
- have the opportunity to become familiar with applications of physics through visits or collaboration with higher education institutions or workplaces at a local or international level
- gain sufficient knowledge for further studies in the natural sciences and fields that use physics
- gain skills in participating in debates and decision-making about the environment and technology.

Research skills

The objective is that students:

- understand the characteristics and the development of natural-scientific knowledge as well as the scientific methods for producing knowledge
- can formulate questions about the phenomena being observed and develop the questions further into starting points for research, problem-solving or other activity
- can plan and carry out experimental research in collaboration with others

- recognise the impact that error sources have on measurements
- can process, interpret and present research results and evaluate them and the whole research process.

Knowledge of physics and its use

The objective is that students:

- can use key concepts in physics logically and in correct contexts
- organise their notions about the structure and phenomena in nature with the help of the concepts and principles of physics
- can express conclusions and viewpoints in the ways that are characteristic of physics
- understand physical phenomena and the principles behind technological applications
- can formulate, interpret and evaluate different models and use them, and simulations, to describe phenomena and make forecasts
- can use appropriate programs as tools for modelling and expressing numerical and graphical solutions and results
- can use diverse information sources and critically evaluate them with the help of their knowledge in physics.

4.4. Assessment

The assessment framework focuses on the achievement of the general objectives in physics, with the emphasis on the module-specific objectives and the mastery of core contents. Assessment and feedback given during the learning process help students understand and develop their competence in physics. At the same time students learn to do self-assessment.

Assessment is based on a broad demonstration of competences and observations of students' conceptual and methodological skills and knowledge. Physical knowledge and its application can be demonstrated in many different ways, such as by explaining, graphical modelling or using mathematical models. In addition to different outputs, students' way of working, such as the formulation of questions, the description of the problem-solving process and students' research skills, will be assessed. Assessment takes into account the ability to work experimentally and collect and use information.

4.4.1. Compulsory studies

FY1 Physics as a natural science (1 credit)

This module gives students a picture of the experimental nature of physics and introduces them to modelling. The central aspect is the building of new information through observations and experiments in a way characteristic of physics. The module develops collaboration skills and creates a foundation for the multidisciplinary and creative competence.

Objectives

The objective for the module is that students:

- explore physics as a systematic, experiment-based science
- explore the proportions of the universe and the structure of matter
- explore the information-gathering methods used in physics
- can plan and carry out simple natural-scientific experiments
- gain experiences that inspire and deepen their interest in physics and the study of physics.

Core contents

- quantity and unit, the SI system
- measuring, collecting results, graphical presentation of results and evaluation of the reliability of results
- graphical models and linear models
- planning and carrying out a simple experimental study.

The core contents of the module can be investigated in, for example, the following thematic contexts: motional effects, density measurements and gravitational acceleration.

FY2 Physics, the environment and society (1 credit)

The module explores how energy is produced, transferred and used and what effects these operations have on the environment, society and people's welfare. The central theme is how the concept of energy manifests itself in these contexts and how the concept of energy structures and defines the debate about the topic and the viewpoints related to it.

Objectives

The objective for the module is that students:

- study energy as a central concept of physics
- know different types of energy and methods of energy production
- can compare the scale of different methods of energy production and their environmental impacts

- obtain skills in participating in debates and decision-making about the environment and technology from the perspective of a sustainable energy economy.

Core contents

- types of energy, energy conservation and energy transformation
- energy production, power, efficiency and energy transfer
- the impact of energy production on the environment and the climate change.

The core contents of the module can be investigated in, for example, the following thematic contexts: chemical energy as an energy source, national energy production and consumption and the use of energy in households.

4.4.2. National optional studies

FY3 Energy and heat (2 credits)

The module explores thermodynamic systems, energy transfer between different systems and the effects of energy transfer. The core contents relate, for example, to energy production, climate change and construction. The module provides skills in participating in debates and decision-making about the environment and technology.

Objectives

The objective for the module is that students:

- deepen their understanding of energy as a central concept of physics
- can examine phenomena related to the thermodynamic state and changes in the state of matter
- can apply the concepts and models for thermodynamics to examining solutions for energy production and to building a sustainable future
- recognise the significance of energy balance and thermal transfer for the climate change.

Core contents

- force as a unit of the strength of interaction
- mechanical work
- thermodynamic system and state variables
- temperature, pressure and hydrostatic pressure

- energy conservation, internal energy, energy transfer and quantity of heat
- heating and cooling of matter and changes in the state of matter
- thermal expansion
- changes in the state of gases and equation of state of an ideal gas.

The core contents of the module can be investigated in, for example, the following thematic contexts: energy production, construction, and energy at home, climate change and the heat engine.

The core contents can be explored with, for example, the following experiments: determining absolute zero (extrapolation), determining the specific latent heat for the evaporation of water and verifying Boyle's law.

FY4 Force and motion (2 credits)

The module deals with uniform and variable motion. The module introduces students to force as a fundamental quantity that describes the interactions between physical objects. It also introduces the way Newton's 2nd law is applied when modelling the impact of force to the change of state of motion. The module explores energy and momentum as key concepts and as conserved quantities.

Objectives

The objective for the module is that students:

- can experimentally examine phenomena related to force and motion
- can produce and analyse graphical presentations of measurement data
- understand the significance of conservation laws in physics
- know the safety aspects related to force and motion.

Core contents

- uniform and uniformly accelerated linear motion
- the interaction between, and the force of, physical objects; Newton's laws
- combined effect of forces, a force diagram and an equation of motion
- weight and friction
- kinetic energy, potential energy and mechanical energy

- the conservation of mechanical energy and the mechanical energy principle
- momentum, impulse, the conservation of momentum and one-dimensional collisions.

The core contents of the module can be investigated in, for example, the following thematic contexts: hydropower and wind power, traffic and sport.

The core contents can be explored with, for example, the following experiments: determining the gravitational acceleration, determining the coefficient of friction and determining the forces affecting a physical object.

FY5 Periodic motion and waves (2 credits)

During the module, students deepen the knowledge and skills learned in previous modules. The module introduces students to harmonic interaction, gravitational interaction and the motion effects caused by them. The module examines and models sound and sound phenomena as mechanical wave motions.

Objectives

The objective for the module is that students:

- can model planetary motion as circular motion
- study the basics of vibratory and wave motion by examining mechanical vibration and sound
- can describe periodic motion with physical and mathematical concepts
- can model mechanical vibration and sound as a periodic motion.

Core contents

- the moment and the rotation of an object
- balance in relation to rotation in simple situations
- uniform circular motion and normal acceleration
- the law of universal gravitation and planetary motion
- periodic motion, time period, frequency and amplitude
- harmonic force, vibratory motion and the potential energy of harmonic force
- creation, propagation and reflection of mechanical waves
- diffraction and interference of mechanical waves and standing waves

- sound as a wave motion, sound intensity level, sound properties and the propagation of sound.

The core contents of the module can be investigated in, for example, the following thematic contexts: pendulums, instruments, acoustics and sound reproduction, the negative effects of noise, protection of hearing, and ultrasound imaging.

The core contents can be explored with, for example, the following experiments: determining the oscillation period of a pendulum, determining the speed of sound and the frequency analysis of sound.

FY6 Electricity (2 credits)

The module introduces students to the main models describing electrical interaction and the concepts of electrical energy and electrotechnology. Students acquire the basic knowledge of the planning and examining of simple electrical circuits. The module also deals with electrical safety and explores applications of electrotechnology.

Objectives

The objective for the module is that students:

- can experimentally examine phenomena related to electricity and carry out basic electrical measurements
- can use the concepts of field and potential when describing an electric field
- know the safety aspects related to electrical devices and transmission of electrical energy.

Core contents

- voltage and electrical current in direct current circuits
- resistance and Ohm’s law
- electric power and Joule effect
- resistor connections and Kirchhoff’s laws
- batteries and battery charging circuits
- Coulomb’s law and the homogeneous electric field
- potential energy and potential in a homogeneous electric field
- capacitor and capacitor energy

- semiconductors, diode and LED as components in a circuit
- electrical safety: fuse, protection rating and dielectric strength.

The core contents of the module can be investigated in, for example, the following thematic contexts: simple electrical devices, solar cell as a source of direct voltage and the storage of electric energy.

The core contents can be explored with, for example, the following experiments: measuring the operation of components in a circuit and the experimental determination of the internal resistance of a battery.

FY7 Electromagnetism and light (2 credits)

The module introduces students to electromagnetism as an area of phenomena, in which electric and magnetic interactions occur at the same time. The module explores time-dependant electromagnetic phenomena, of which the main one is electromagnetic induction. The module also deals with electromagnetic radiation and especially the most familiar form of it, the light. This focuses on applications of electromagnetism that are significant as enablers of the development of society.

Objectives

The objective for the module is that students:

- understand that induction is of central importance in electromagnetism
- understand the basics of the production and transmission of electrical energy and their importance for the functioning of society
- recognise sources of electromagnetic radiation and their effects
- understand light as an electromagnetic phenomenon.

Core contents

- ferromagnetism and the magnetic dipole
- magnetic interaction and magnetic fields
- motion of a charged particle in an electric and magnetic field
- the magnetic field of a current-carrying conductor and the force between two current-carrying conductors
- electromagnetic induction, Lenz’s law and eddy currents

- generator, the generation of alternating current, transformers and the transfer of energy with the help of electric current
- electromagnetic radiation and its spectrum and the spectrum of black body radiation
- reflection, refraction and total internal reflection
- interference and diffraction of light
- the polarisation of light (qualitative).

The core contents of the module can be investigated in, for example, the following thematic contexts: particle accelerator, switching technology, wind power and optical data transfer.

The core contents can be explored with, for example, the following experiments: determining the magnetic flux density inside a coil, examining the reflection and refraction of light at an interface and determining the wavelength of a laser with a diffraction grating.

FY8 Matter, radiation and quantisation (2 credits)

The module introduces the students to the conceptual and theoretical structures of quantum physics and their experimental basis. The focus is on the structure and basic interactions of matter and how these impact on the properties of the matter. The module deals with the technical applications of quantum physics and how quantum physics manifests itself, from the phenomena at elementary particle level through phenomena at nanoscale to cosmic scale. The module also explores different technologies that are based on radioactive decay, ionising radiation and quantisation.

Objectives

The objective for the module is that students:

know the effects of ionising radiation and learn the safe use of radiation

explore a world view based on quantum physics, from the elementary particle physics to cosmology

understand the significance of technology based on quantisation for modern society.

Core contents

- quantisation of energy in the interaction of matter and radiation
- the photon as a quantum of an electromagnetic radiation field
- the structure of the atom, the quantum states of the electrons in the atom and the principle of the wave-mechanical model for the atom
- technology based on quantisation: laser and quantum structures

- the structure of an atomic nucleus and changes in an atomic nucleus, radioactive decay
- nuclear reactions, mass–energy equivalence, nuclear binding energy
- nuclear power, fission and fusion
- the radioactive decay law
- the types and biological effects of ionising radiation and its application in medicine and technology
- standard model for particle physics
- the evolution of the universe.

The core contents of the module can be investigated in, for example, the following thematic contexts: radiation safety, use of radiation in medicine, the climate change and the greenhouse effect.

The core contents can be explored with, for example, the following experiments: measuring the spectrum, observing the change of spectrum in the fluorescence phenomenon, measurements with laser diodes and simulations related to the topic of the module.

5. CHEMISTRY

5.1. The goal of the subject

The instruction in chemistry supports the development of students' natural-scientific thinking and modern world view as part of a diverse general education. Students learn to understand the significance of chemistry for everyday life, society and solving environmental challenges. The instruction introduces students to the language, the terminology and the ways of developing knowledge of the subject and associated disciplines. As students' natural-scientific literacy improves, it helps students critically evaluate various everyday choices and viewpoints in a social debate. The instruction develops students' curiosity about the study of chemistry; the professions in the chemistry field; and provides students with the skills to succeed in further studies in the natural science fields and in fields applying natural sciences. Diverse learning situations and environments encourage opportunities for an egalitarian and equal way of learning.

The instruction in chemistry supports the understanding of concepts and phenomena in such a way that their macroscopic, microscopic and symbolic levels integrate into a logical whole. Using students' previous experiences and observations as a starting point, the instruction explores describing and explaining phenomena as well as modelling the structure of matter and chemical reactions mathematically and by using chemical notation.

The instruction in chemistry employs varied and versatile teaching and learning methods, which develop students' conceptual and methodological competence. Observation and examination are central aspects in the instruction. Experimentation in its different forms supports the adopting and understanding of concepts, the learning of research skills and the understanding of the character of natural sciences. Experimental work is carried out in accordance with the legislation related to chemical, waste and occupational safety. Students learn to take responsibility for common safety, which also develops the safety competence required in the working life.

As studies progress, students develop their overall research skills as well as those in relation to the core contents of each module. Asking questions and making observations is the basis of research skills. The skills in measuring and classification and other research skills are improved by practising different methods. Students' skills in processing and presenting information are also improved. Students develop their skills in experimental work towards the planning of one's own research. At the same time, students learn to draw conclusions and evaluate and present arguments about research results.

5.2. Transversal competence in the subject

The instruction in chemistry provides students with skills and knowledge that help them understand the importance of chemistry in their everyday lives, health and the environment, which supports the objectives of the **welfare competence**. Students gain the ability to make choices in their everyday lives which are beneficial to their own personal health, the environment and society. The learning methods in chemistry support a way of working in which students identify their personal strengths and set their own goals. Methodological study is an

important everyday skill which strengthens students' ability to cope and work, also in changing circumstances.

The experimental nature of the instruction in chemistry and students' own experimental work develop their working and collaboration skills; their critical thinking; and inspire students to study chemistry. Students develop their **interaction competence**, they learn perseverance and to take responsibility for their own work with the help of versatile working methods, such as project learning and working in groups.

The instruction in chemistry makes students aware of the difference between the accurate usage of the language of chemistry and the everyday language. The universal language of chemistry is explored using students' own observations and the everyday language as starting points. In chemistry, the importance of language awareness and language knowledge is illustrated in particular through learning the terminology and through clear and logical reasoning of one's own conclusions.

During the study of chemistry, students practise writing, critical interpretation of, presenting arguments about and analysing different texts. Multiliteracy skills are developed by interpreting and producing, for example, written text, pictures, videos, models, simulations, tables, diagrams and chemical notation. In chemistry, a specific form of multiliteracy is the skill to interpret and present symbolic models and sub-microscopic pictorial models for the same phenomena. Information and communication technology is also part of the current instruction in chemistry which supports students' **multidisciplinary competence**. It is used, among other things, for searching for information, collecting experimental observations, processing and interpreting measurement results, composing and presenting work as well as modelling and simulating. Computer-based measuring systems can replace traditional tools, and there is the possibility to save research data as pictures and videos.

In the natural-scientific working, the **creative competence** is demonstrated through the ability to formulate questions about the phenomena being observed and to apply, evaluate, combine and analyse the collected data. Experimental working and problem-solving require a creative approach, and they develop creative thinking.

The instruction in chemistry supports students' **social competence** and their **global and cultural competence**. The instruction develops students' ability to participate in social debate and joint decision-making by deepening their natural-scientific thinking and their understanding of the reliability, importance and use of information. The historic development of the natural science information provides students a perspective to the development of a scientific world view and the significance of chemistry for social changes. Through the innovations in chemistry and the modern applications of chemistry, students learn to understand the importance of chemistry for modern society, technology and the working life. Chemistry is required for developing new solutions and ensuring environmental and human welfare locally, nationally and internationally.

The instruction in chemistry enforces students' **ethics and environmental competence** by deepening their understanding of various environmental problems and their reasons. The instruction steers students towards taking responsibility for their own actions and the environment, using their competence in chemistry in the building of a sustainable future, and evaluating their own choices in relation to the sustainable use of natural resources and the

circular economy. Students identify solutions provided by chemistry for various environmental challenges, such as the climate change and the safeguarding of natural resources.

5.3. The general objectives for the instruction in chemistry

The general objectives for the instruction in chemistry relate to the significance, values and approaches of chemistry and to the knowledge in chemistry and its use. The general objectives for the instruction are described in detail below.

Meaning, values and attitudes

The objective is that students:

- obtain guidance in identifying their own competence in chemistry, setting their own goals, meeting learning challenges and applying learning strategies in chemistry
- can evaluate the solutions provided by chemistry and related technologies and their significance for an individual, the environment and society
- have opportunities to become familiar with the applications of chemistry through visits or collaboration with higher education institutions or workplaces at a local or international level
- obtain sufficient knowledge for further studies in the natural sciences and in fields that apply chemistry.

Research skills

The objective is that students:

- understand the properties and the development of natural-scientific knowledge and the scientific methods for producing knowledge collaboratively
- are familiar with the safe working methods in chemistry and can deal in an appropriate manner with the chemical waste that is produced
- can formulate questions about the phenomena being observed and develop the questions further into starting points for research and problem-solving
- can carry out experimental research using working methods typical of chemistry
- can process, interpret and present research results and analyse and evaluate them and the whole research process.

Knowledge in chemistry and its use

The objective is that students:

- can use and employ key concepts in chemistry

- can use different models to describe and explain phenomena and make forecasts
- can make versatile use of appropriate programs as tools for modelling and expressing numerical and graphical solutions and results
- can use diverse information sources and critically evaluate information presented in different contexts by applying their knowledge in chemistry.

5.4. Assessment

The assessment framework focuses on the attainment of the general objectives in chemistry, with the emphasis on the module-specific objectives and the mastery of core contents. Assessment and feedback given during the learning process and self-assessment help students become aware of and develop their competence in chemistry.

Assessment takes into account students' ability to understand, illustrate and present chemical information. It also evaluates students' ability to apply chemical information; understand the fundamental principles of natural sciences and the cause-effect relations; and the overarching view of the whole. Assessment takes into account students' ability to critically evaluate information.

Assessment is based on a broad demonstration of competences and observations of students' conceptual and methodological skills and knowledge. The understanding and application of chemical information can be demonstrated in various ways. In addition to different outputs, students' working skills, such as the formulation of questions and their research skills are also assessed. Assessment takes into account the ability to work experimentally and collect and use information.

5.4.1. Compulsory studies

KE1 Chemistry and I (1 credit)

The module reinforces students' existing competence in chemistry and the significance of chemistry for their own lives. Exploring the concept of the amount of a substance introduces students to the quantitative side of chemistry. During the experimental work, students learn safe and careful ways of working. The module emphasises the transversal objectives of the welfare competence and the social competence.

Objectives

The objective for the module is that students:

- gain experiences that inspire and deepen an interest in chemistry and the study of chemistry, and learn about the professions and the opportunities for further studies in the field of chemistry
- gain the ability to participate in a social debate related to chemistry and can evaluate the reliability of information sources
- learn to use the periodic table as a tool for chemical reasoning

- can use and apply information about the properties of substances and their safety in everyday choices
- can experimentally examine the chemical composition and concentration of a mixture and observe the occupational safety aspects.

Core contents

- evaluating the safety of everyday substances and the significance of chemistry for students' own lives
- the importance of chemistry in the working life and further studies
- the periodic table and the structure of the atom with the electron shell model
- pure substances, mixtures and separation techniques
- amount of substance and concentration.

The core contents of the module can be investigated in, for example, the following contexts: food and food additives, trace elements, health and consumer choices.

The core contents can be explored with, for example, the following experimental investigations: determining the chemical composition or concentration using separation techniques and flame tests.

KE2 Chemistry and a sustainable future (1 credit)

In this module, students deepen their understanding of chemical bonds and their importance to the properties of a substance. Students practise drawing conclusions from observations specifically during the experimental work. The module also introduces natural-scientific solutions for promoting a sustainable lifestyle. The module emphasises the transversal objectives of the multidisciplinary and creative competence and the social competence.

Objectives

The objective for the module is that students:

- gain experiences that inspire and deepen an interest in chemistry and the study of chemistry, and learn about the importance of chemistry in promoting a sustainable lifestyle
- learn the properties and the development of natural-scientific knowledge and the scientific methods for producing knowledge
- can experimentally examine the properties of a substance

- can apply the models for the chemical structure of a substance when comparing the properties of the substance
- understand the significance of chemistry to the environment and society as a way of providing solutions together with other natural sciences.

Core contents

- exploring examples of promoting a sustainable lifestyle in natural sciences
- presenting models for the chemical structure of a substance and the formula for a compound
- weak and strong bonds and polarity of elements and compounds
- examining experimentally the properties of substances and explaining them with the help of the chemical structure of a substance.

The core contents of the module can be investigated in, for example, the following contexts: water and air, cycle of chemical elements and sufficiency of chemical elements, life cycle thinking and the circular economy, green chemistry and the historic development of atomic and bond models.

The core contents can be explored with, for example, the following experimental investigations: examining the properties of substances and explaining them with the help of bonds, examining the properties of water.

5.4.2. National optional studies

KE3 Molecules and models (2 credits)

The module deals with carbon compounds, their structure and properties. Information and communication technology is used for modelling molecules. The significance of carbon compounds for students' lives is explored in relation to health and welfare. The module also emphasises the transversal objectives of social competence and global competence.

Objectives

The objective for the module is that students:

- can use and apply the knowledge of carbon compounds to everyday phenomena
- can apply the concepts of the amount of a substance and the concentration
- can examine carbon compounds experimentally by using different models
- understand how the knowledge of carbon compounds is developed through experimental activities and related modelling

- can use information and communication technology as a tool for modelling.

Core contents

- preparing and diluting a solution and adapting a standard curve to determine concentration
- the functional groups of hydrocarbons, carbon-oxygen and carbon-nitrogen compounds, and the basics of naming
- oxidation and reduction in the carbon-oxygen compounds
- modelling the structures of carbon compounds and explaining the properties with the help of the structure
- determining the empirical formula and molecular formula by a numerical method and structural isomerism
- quantum mechanical atomic model, hybridisation and stereoisomerism in carbon compounds
- exploring the information from spectra about the structure of matter.

The core contents of the module can be investigated in, for example, the following contexts: simple molecules in everyday life and the living environment, cosmetics as well as medicine and other substances with physiological effects.

The core contents can be explored with, for example, the following experimental investigations: examining the properties of carbon compounds; identifying carbon compounds with the help of detection reactions of functional groups; preparing and diluting a solution; and determining the concentration of a solution with a standard curve and a linear model.

KE4 Chemical reaction (2 credits)

The module deals with different chemical reactions and their significance in the living environment. The exploration of reactions progresses from observations to deducing the reaction products and writing the chemical equation. A chemical equation is also used in the quantitative analysis of a reaction. The contents of the module enable group work and an experimental working method, which emphasise the transversal objectives of the multidisciplinary and creative competence and the interaction competence.

Objectives

- The objective for the module is that students:
- obtain an overall picture of the diversity of chemical reactions and their significance for our living environment

- can use and employ the concepts of chemical reactions in everyday, environmental and social phenomena and in the applications of modern technology
- can examine chemical reactions experimentally and using different models
- understand the significance of the conservation of matter in chemistry.

Core contents

- experimentally examining reactions and processing, interpreting and presenting research results
- symbolic representation and balancing of a chemical reaction, the formulas and names of reaction products
- yield and limiting factor in a chemical reaction
- equation of the state of an ideal gas and the amount of a substance
- precipitation and decomposition reaction, combustion reaction
- protolysis, neutralisation and titration as methods for analysis
- addition, elimination, substitution, condensation and hydrolysis in carbon compounds and the formation of the most common biomolecules
- polymerisation reactions and the properties, use and lifecycle of polymers.

The core contents of the module can be investigated in, for example, the following contexts: the significance of yield for green chemistry; combustion products and air quality; biomolecules in nutrition; polymer materials in clothing and everyday utensils; bioproduction technology and modern materials.

The core contents can be explored with, for example, the following experimental investigations: determining the yield of a reaction; observing a gas generating reaction and detection reactions; synthesis and hydrolysis of ester; production of biomaterial; and examining the properties of plastics.

KE5 Chemical energy and circular economy (2 credits)

The module deals with chemical energy and the storage and recovery of energy. It introduces students to the planning of a natural-scientific research and examines oxidation and reduction reactions and their applications. The module emphasises the transversal objectives for ethics and environmental competence as well as the objectives for the interaction competence.

Objectives

The objective for the module is that students:

- understand the principles of storage and recovery of chemical energy, and can justify their opinions in a debate about energy solutions
- understand the conservation of energy and the energy changes in chemical reactions
- know the properties of significant metals and the production and refining processes and their environmental impacts
- can experimentally examine phenomena associated with electrochemistry and describe them using models
- know the principles of recycling metals which are important to society and of the circular economy as well as the related solutions.

Core contents

- energy absorbed or released in a reaction with the help of enthalpy of formation, binding energies and Hess's law
- the principles of calculations of reaction series and mixture
- oxidation numbers and oxidation-reduction reactions
- properties and uses of metals, production and refining processes, sufficiency of supply and recyclability
- the core principles of electrochemistry: voltage series, standard potential, chemical pair, electrolysis and storage of chemical energy
- exploring the natural-scientific research or the conception and planning of research and problem-solving.

The core contents of the module can be investigated in, for example, the following contexts: reaction series in industrial processes; the significance of extractive industries for society; the production, storage and use of energy in a renewable energy economy; and hybrid energy.

The core contents can be explored with, for example, the following experimental investigations: determining dissolution or reaction enthalpy in calorimeters; oxidation-reduction titration; measuring voltage of an electrochemical pair; electroplating an object; electrolysis of water; and exploring the operation of a fuel cell.

KE6 Chemical equilibrium (2 credits)

The module introduces the concept of the chemical equilibrium and its quantitative and qualitative analysis. Research results are interpreted and presented graphically using information and communication technology. The module emphasises the transversal objectives of the welfare competence as well as the ethics and environmental competence.

Objectives

The objective for the module is that students:

- recognise the significance of chemistry for solving health and environmental problems
- can experimentally examine phenomena related to the reaction rate and chemical balance
- can use numerical and graphical models in describing, explaining and predicting reaction rate and chemical balance
- can present research results graphically and evaluate the research results and the research process
- learn about equilibrium reactions in industrial processes and in nature and their significance.

Core contents

- rate of chemical reaction and factors influencing it
- qualitative and quantitative treatment of homogeneous equilibrium with concentrations, influencing the state of equilibrium
- acids and bases and the associated concepts, the reactions of combustion products in water
- numerical treatment of acid-base-equilibrium
- the functional principle of buffer solutions, and the buffer systems of the body and of nature at a qualitative level
- experimentally examining phenomena associated with reaction rate and equilibrium reactions, and modelling and analysing phenomena graphically with a computer application
- exploring the opportunities offered by chemistry for solving a health or an environmental problem.

The core contents of the module can be investigated in, for example, the following contexts: water and water purification; prevention of acidification and climate change; cleaning of combustion gases; the efficiency of the production method of a medication or a basic chemical; and the evaluation of the environmental impacts.

The core contents can be explored with, for example, the following experimental investigations: determining the reaction rate by observing the change in mass; drawing titration curves for strong and weak protolytes; influencing the state of equilibrium, such as complexing; producing a buffer solution and examining the buffering capacity.