



## Syllabus of the International Junior Science Olympiad - IJSO

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### Aims of the syllabus

The syllabus of the International Junior Science Olympiad (IJSO) lists the skills and areas of knowledge the participants should be familiar with for this competition.

It thus serves as a guideline for developing tasks to the Scientific Committees of the hosting countries but should also help the leaders of the participating countries to effectively train their students for this competition.

In order to keep the syllabus up to date it should be revalidated every three years and if necessary shortened or expanded.

### Structure and content of the syllabus

The International Junior Science Olympiad is a general science competition. The IJSO syllabus is therefore not strictly divided into the disciplines biology, chemistry and physics but rather intends to highlight basic general concepts in science.

This conceptual approach is also meant to encourage the development of problems of interdisciplinary content and relevance.

The content of the syllabus is based on

- the former syllabus of the IJSO,
- the syllabi for students up to 15 years of age in the participating countries,
- the problems given at the IJSO until the 5<sup>th</sup> IJSO in 2008.

Omissions and additions were made if considered suitable.

### Remarks about problems given at the IJSO

More complex or additional topics may be investigated in the problems provided sufficient information to work on the questions is given in the problems themselves. This may include topics in science that are not listed below as well as the use of sophisticated apparatus in the experiments. The additional topics will not compose more than 10 % of any paper.

All Problems should be given using SI-units. If other units are used the conversion to SI-units should be explained. A list including all the natural constants used in the tests should be provided.

The experimental problems at the IJSO should only employ equipment that most of the students are familiar with and that may be found at schools. Furthermore they should not involve dissection of animals.

## A. General science skills

As a general prerequisite the students should be familiar with and be able to

- employ and explain scientific methods,
- use scientific terminology,
- put forward hypotheses,
- devise and accurately describe methods/experiments to test hypotheses,
- assess the validity of different sources of information and be aware that data might be inaccurate or even wrong,
- adequately represent data in tables, diagrams and graphs,
- interpret data.

## B. Content Knowledge in Natural Sciences and Mathematics

### 1. Particles, waves and matter

Matter is structured from the smallest particle to the size of the universe. The microscopic structure of matter is responsible for the features we observe macroscopically. The students should be aware of this structure and be familiar with the following concepts:

- What things are made of
  - Structure of particles and atoms  
(*neutrons, protons, electrons, nature of bonding*)
  - Elements, isotopes and compounds
  - Composition of molecules, chemical substances
  - Mixtures, colloids and suspensions
- Periodic table - concept, organization and structure
- States of matter and its properties
  - Solids, liquids, gases and plasmas - characteristics and differences
  - Lattices as a special form of solid matter
  - Properties of matter  
(*density, volume, electrical conductivity, insulators and conductors, elastic behaviour, thermal expansion, (specific) heat capacity, defining properties of metals, non-metals, alloys*)
  - Phase transitions and their influence on the properties of matter  
(*latent heat, phase diagrams, change of volume and density*)
  - Water and its different phases
- Waves
  - Frequency, wavelength, speed of propagation and its relation
  - Difference between transversal and longitudinal waves
  - Superposition of waves
  - Classical Doppler effect
- Sound  
(*Sound as longitudinal pressure wave, perception of sound*)

- Light
  - Wave and particle interpretation of light
  - Propagation and speed of light in vacuum and media, refractive index
  - Connection between wavelength and colour, electromagnetic spectrum
  - Reflection and refraction of light at mirrors and lenses  
*(angle of incident and reflected beams, snell's law, total internal reflection)*
  - Formation of images with mirrors and lenses  
*(focal length, thin lens formula, magnification, magnifying glasses, microscopes, telescopes, glasses)*

## 2. Energy

Energy is essential in our everyday life as energy conversion is the reason for many dynamical phenomena in our world. Energy is therefore one of the main concepts in science. The students are expected to know about the following topics:

- Nature of energy and energy conservation
- Various forms of energy  
*(bonding energy, kinetic energy, potential energy, heat, activation energy, energy stored in a spring)*
- Transfer of energy  
*(e.g. mechanisms of heat transfer, transfer of energy via waves)*
- Energy conversion / transformation and its efficiency  
*(e.g. conversion between potential and kinetic energy, bonding energy and temperature or the loss of energy to the environment by radiation)*
- Sources of energy  
*(e.g. for animals, plants, societies and engines. Fossil and renewable energy sources)*
- Power  
*(e.g. muscular power, power output of engines or stars, power dissipation in resistors)*

## 3. Interactions

Conversion of energy and our perception of the world around us are only possible due to interactions. The students should know about and be able to work with the following concepts:

- Forces
  - Nature of forces and types of forces  
*(gravitational force, electrostatic force, magnetic force, static and dynamic frictional forces, buoyancy, Van-der-Waals force)*
  - Mass and weight, centre of mass
  - Newton's laws, inertial systems
  - kinematics of a point mass: linear and circular motion  
*(position, speed, acceleration, angular frequency, centripetal force, Kepler's laws, movement of the earth around the sun)*
  - Momentum and change of momentum  
*(linear momentum, elastic and inelastic collisions, conservation of momentum in closed systems)*
  - Levers
  - Elastic forces, Hooke's law and harmonic motions

- Pressure  
(*atmospheric pressure, static pressure in liquids*)
- Electric, magnetic and gravitational fields
- Type of chemical bonding - nature, structure and strength  
(*covalent and ionic bonds, hydrogen bonding and van-der-Waals interaction*)
- Chemical Reactions
  - Chemical equations - balancing and stoichiometry
  - Types of chemical reactions  
(*acid/base neutralisations, redox reactions, thermal decompositions*)
  - Basic and most common reactions for determination of unknown substances
  - Rate of reactions, factors affecting reaction rate like catalysts, temperature and concentration
  - Dynamic equilibrium and Le Chatelier's principle
  - Common ion effect
- Diffusion, osmosis and surface tension
- Principle of thin layer and paper chromatography
- Effects of radiation on organisms
- Forms of communication  
(*e.g. function of hormones and pheromones in living organisms*)

#### 4. Structure, properties and functions

The different constituents of a system usually have specific properties which allow them to fulfil their function in the intended way. The students should know the structure of the following components and understand in which way they fulfil their functions

- Cells
  - Basic structure of cells and its constituents
  - differences between animal, plant cells and bacteria
  - Basic concepts of the biochemistry of molecules - carbohydrates, proteins, lipids and nucleic acids
- Parts of the body
  - Anatomy and function of main organs and tissues in animals and humans  
(*lung, heart, kidney, liver, digestive system, sensory organs, skin, blood*)
  - Properties of muscles
- Homogeneous and heterogeneous catalysts
- Acids and bases
  - Properties of acids and bases
  - pH values and neutralisation
  - Indicators
  - Formation and effect of acidic rain
  - Electrolysis  
(*migration of ions, Faraday constant, electrochemical cells*)

## 5. Systems

Things in life are organized in open or closed systems. It is therefore important to not only look at the components of a system and its interdependencies but also at the system as a whole. The students should be able to employ the concepts of

- Continuity principles in closed systems/cycles
- Equilibriums  
(*e.g. of forces, chemical/ionic equilibrium, thermodynamical equilibrium, ecosystems in equilibrium*)
- Scales of nature  
(*e.g. in biological systems, astrophysics*)
- Basic concepts about cycles in nature  
(*carbon cycle, water cycle, Nitrogen cycle, oxygen cycle, ozone cycle, renewable and non-renewable natural resources, earth's climate*)
- Ecology
  - Levels of organization in the biosphere
  - Factors affecting ecosystems (abiotic and biotic)
  - Interactions between organisms  
(*e.g. competition, predation, mutualism*)
  - Producers, consumers and decomposers
  - Food chains, food webs
  - Basic principles of conservation of biodiversity
  - Factors affecting growth of populations, typical growth-curves for populations
- Pollution effects of different modes of power generation
- Organisms as systems
  - Transformation of matter and energy in organisms
  - Basic knowledge of digestive, circulatory, respiratory, excretory, nervous, immune and endocrine systems
- Plant physiology
  - Respiration and exchange of gases
  - Absorption by roots, diffusion, osmosis
  - Photosynthesis
  - Tropism of plants
- Electric Circuits
  - Components of circuits  
(*resistors and wires, bulbs, voltage sources, Ammeters, Voltmeters, capacitors*)
  - Ohm's law, charge, current, voltage
  - Series and parallel circuits, Kirchhoff's laws
  - Difference between AC and DC currents/voltages
  - Qualitative knowledge of electromagnetic induction and Lenz's law
  - Basic principles of generators and motors
- Thermodynamical systems  
(*(absolute) temperature, ideal gas law, isothermal, isochoric and isobaric processes, Hess's law, combustion cycles*)

- Astrophysical systems  
(*main characteristics of stars, planets, moons, comets, asteroids, solar systems, galaxies*)

## 6. Development and Evolution

Living organisms are not static and undergo constant change and adaptation. The students are expected to show proficiency in the following areas:

- Strategies of environmental adaptation  
(*characteristics of adaptation, structural, physiological and behavioural adaptation*)
- Theory of evolution  
(*natural selection, neo-Darwinian revolution, evidence of evolution*)
- Cell cycle and cell division  
(*basic principles of meiosis, mitosis, haploidy and diploidy*)
- Reproduction in humans, animals and plants
  - principles of creation of new life
  - human reproductive organs and sex cells
  - changes that take place in boy's and girl's bodies during puberty
  - basic principles of plant reproduction (asexual and sexual)
  - basic knowledge of the development of foetus during pregnancy
- Genes, chromosomes and genetics  
(*mendel's laws, mutations, inheritance of genetic characteristics*)
- Diseases
  - cause and transmission of diseases  
(*microorganisms causing common diseases, viruses, genetic defects*)
  - immune systems
  - principles of vaccination
  - antibiotics such as the penicillin group

## 7. Mathematics skills

The emphasis of the tests should be on natural sciences. Nevertheless mathematics is an indispensable tool to the natural sciences. The students should therefore know about and be able to make use of

- equations involving
  - fractions
  - logarithms and exponential functions
  - powers and roots
  - polynomials (e.g. solving quadratic equations)
  - trigonometric functions
- transformations of equations to obtain linear relations
- plots of functions
- simple geometry (geometry of triangles and circles, areas and volumes of basic planar forms and solids)
- basic vector algebra (decomposition and addition of vectors)
- simple statistics (mean values, standard deviations, basic notion of probabilities)

- error estimation  
(by means of standard deviation or Min-Max analysis, difference between accuracy and precision)
- rounding of numbers and representing data with the proper number of digits / significant figures

## C. Laboratory Skills

The content knowledge and general science skills part of the Syllabus provide the basis for all the experimental problems. In addition the students should be familiar with laboratory work. They should in particular be able to

- work in the laboratory following safety regulations
- employ basic techniques for measuring the quantities mentioned in part B
- make observations using the five senses
- identify and use basic laboratory equipment
- use more sophisticated equipment if proper instructions are given
- collect data from an experiment being aware that instruments affect measurements
- identify error sources and estimate their effects