

Syllabus of

International Olympiad on Astronomy and Astrophysics (IOAA)

General Notes

1. Extensive contents in basic astronomical concepts are required in theoretical and practical problems.
2. Basic concepts in physics and mathematics at high school level are required in solving the problems. Standard solutions should not involve use of calculus and/or the use of complex numbers and/or solving differential equations.
3. Astronomical software packages may be used in practical and observational problems. The contestants will be informed the list of software packages to be used at least 3 months in advance. The chosen software packages should be preferably freewares or low-cost ones enabling all countries to obtain them easily for practice purpose. The chosen softwares should preferably be available on multiple OSs (Windows / Unix / GNU-Linux / Mac).
4. Concepts and phenomena not included in the Syllabus may be used in questions but sufficient information must be given in the questions so that contestants without previous knowledge of these topics would not be at a disadvantage.
5. Sophisticated practical equipments likely to be unfamiliar to the candidates should not dominate a problem. If such devices are used in the questions, sufficient information must be provided. In such case, students should be given opportunity to familiarise themselves with such equipments.
6. The original texts of the problems have to be set in the SI units, wherever applicable. Participants will be expected to mention appropriate units in their answers and should be familiar with the idea of correct rounding off and expressing the final result(s) and error(s) with correct number of significant digits.

A. Theoretical Part

Symbol (Q) is attached to some topics in the list. It means “qualitative understanding only”. Quantitative reasoning / proficiency in these topics is not mandatory.

The following theoretical contents are proposed for the contestants.

1. Basic Astrophysics

Contents	Remarks
Celestial Mechanics	Newton’s Laws of Gravitation, Kepler’s Laws for circular and non-circular orbits, Roche limit, barycentre, 2-body problem, Lagrange points
Electromagnetic Theory & Quantum Physics	Electromagnetic spectrum, Radiation Laws, Blackbody radiation
Thermodynamics	Thermodynamic equilibrium, Ideal gas, Energy transfer
Spectroscopy and Atomic Physics	Absorption, Emission, Scattering, Spectra of Celestial objects, Doppler effect, Line formations, Continuum spectra, Splitting and Broadening of spectral lines, polarisation
Nuclear Physics	Basic concepts including structure of atom, Mass defect and binding energy Radioactivity, Neutrinos (Q)

2. Coordinates and Times

Contents	Remarks
Celestial Sphere	Spherical trigonometry, Celestial coordinates and their applications, Equinox and Solstice, Circumpolar stars, Constellations and Zodiac
Concept of Time	Solar time, Sidereal time, Julian date, Heliocentric Julian date, Time zone, Universal Time, Local Mean Time, Different definitions of “year”, Equation of time

3. Solar System

Contents	Remarks
The Sun	Solar structure, Solar surface activities, Solar rotation, Solar radiation and Solar constant, Solar neutrinos (Q), Sun-Earth relations, Role of magnetic fields (Q), Solar wind and radiation pressure, Heliosphere (Q), Magnetosphere (Q)
The Solar System	Earth-Moon System, precession, nutation, libration, Formation and evolution of the Solar System (Q), Structure and components of the Solar System (Q), Structure and orbits of the Solar System objects, Sidereal and Synodic periods, Retrograde motion, Outer reaches of the solar system (Q)
Space Exploration	Satellite trajectories and transfers, Human exploration of the Solar System (Q), planetary missions (Q), Sling-shot effect of gravity, Space-based instruments (Q)
Phenomena	Tides, Seasons, Eclipses, Aurorae (Q), Meteor Showers

4. Stars

Contents	Remarks
Stellar Properties	Methods of Distance determination, Radiation, Luminosity and magnitude, Color indices and temperature, Determination of radii and masses, Stellar motion, Irregular and regular stellar variabilities – broad classification & properties, Cepheids & period-luminosity relation, Physics of pulsation (Q)
Stellar Interior and Atmospheres	Stellar equilibrium, Stellar nucleosynthesis, Energy transportation (Q), Boundary conditions, Stellar

	atmospheres and atmospheric spectra
Stellar Evolution	Stellar formation, Hertzsprung-Russell diagram, Pre-Main Sequence, Main Sequence, Post-Main Sequence stars, supernovae, planetary nebulae, End states of stars

5. Stellar Systems

Contents	Remarks
Binary Star Systems	Different types of binary stars, Mass determination in binary star systems, Light and radial velocity curves of eclipsing binary systems, Doppler shifts in binary systems, interacting binaries, peculiar binary systems
Exoplanets	Techniques used to detect exoplanets
Star Clusters	Classification and Structure, Mass, age, luminosity and distance determination
Milky Way Galaxy	Structure and composition, Rotation, Satellites of Milky Way (Q)
Interstellar Medium	Gas (Q), dust (Q), HII regions, 21cm radiation, nebulae (Q), interstellar absorption, dispersion measure, Faraday rotation
Galaxies	Classifications based on structure, composition and activity, Mass, luminosity and distance determination, Rotation curves
Accretion Processes	Basic concepts (spherical and disc accretion) (Q), Eddington luminosity

6. Cosmology

Contents	Remarks
Elementary Cosmology	Expanding Universe and Hubble's Law, Cluster of galaxies, Dark matter, Dark energy (Q), Gravitational lensing, Cosmic Microwave Background Radiation, Big Bang (Q), Alternative models of the Universe (Q), Large scale structure (Q), Distance measurement at cosmological scale, cosmological redshift

7. Instrumentation and Space Technologies

Contents	Remarks
Multi-wavelength Astronomy	Observations in radio, microwave, infrared, visible, ultraviolet, X-ray, and gamma-ray wavelength bands, Earth's atmospheric effects
Instrumentation	Telescopes and detectors (e.g. charge-coupled devices, photometers, spectrographs), Magnification, Focal length, Focal ratio, resolving and light-gathering powers of telescopes, Geometric model of two element interferometer, Aperture synthesis, Adaptive optics, photometry, astrometry

B. Practical Part

This part consists of 2 sections: observations and data analysis sections. The theoretical part of the Syllabus provides the basis for all problems in the practical part.

The observations section focuses on contestant's experience in

1. naked-eye observations,
2. usage of sky maps and catalogues,
3. application of coordinate systems in the sky, magnitude estimation, estimation of angular separation

4. usage of basic astronomical instruments—telescopes and various detectors for observations but enough instructions must be provided to the contestants.

Observational objects may be from real sources in the sky or imitated sources in the laboratory. Computer simulations may be used in the problems but sufficient instructions must be provided to the contestants.

The data analysis section focuses on the calculation and analysis of the astronomical data provided in the problems. Additional requirements are as follows:

1. Proper identification of error sources, calculation of errors, and estimation of their influence on the final results.
2. Proper use of graph papers with different scales, e.g., polar and logarithmic papers. Transformation of the data to get a linear plot and finding “Best Fit” line approximately.
3. Basic statistical analysis of the observational data.
4. Knowledge of the most common experimental techniques for measuring physical quantities mentioned in Part A.