SILABUS

OLIMPIADE ASTRONOMI INTERNASIONAL

UNTUK SELEKSI OLIMPIADE SAINS NASIONAL TINGKAT KABUPATEN/KOTA, PROVINSI, DAN NASIONAL

ASTRONOMI

Kementerian Pendidikan dan Kebudayaan
Direktorat Jenderal Pendidikan Dasar dan Menengah
Direktorat Pembinaan Sekolah Menengah Atas

Materi

Teori

I. Astrofisika

1. Hukum radiasi, radiasi *blackbody*, efek Doppler, spektrum elektromagnetik;
2. Spektroskopi: absorpsi, emisi, hamburan, spektrum benda langit, pembentukan garis, spektrum kontinum, pemisahan dan pelebaran garis spektrum, polarisasi;
3. Fotometri: Sistem magnitudo, luminositas, indeks warna&temperature, ekstingsi atmosfer, satuan fisis fotometri, spektrofotometri;
4. Struktur atom, energi ikat, radioaktif, neutrino;
5. Kesetimbangan termodinamika, gas ideal, transfer energi,
6. Hukum Radiasi: hukum kuadrat kebalikan, intensitas, luminositas, kecerlangan dan jarak, magnitudo semu dan absolut, modulus jarak, radius bintang, diagram Hertzprung-Russell,
7. Radiasi Benda Hitam: hukum Rayleigh-Jeans, hukum Planck, hukum pergeseran Wien, hukum Stefan-Boltzmann, warna dan kelas spektrum bintang, dan kelas luminositas bintang,
8. Sifat-sifat cahaya: dualisme gelombang dan partikel dari cahaya, garis emisi dan absorpsi, spektrum elektromagnet, hukum Kirchoff, model atom Bohr, dan efek Doppler.

II. Astronomi Bola

1. Trigonometri bola: formula-formula pada segitiga bola.
2. Koordinat langit dan aplikasinya: sistem koordinat geografis Bumi, sistem koordinat horizontal, sistem koordinat equatorial, sistem koordinat ekliptika, sistem koordinat galaktik; transformasi koordinat;
3. *Equinox* dan *solstice*, bintang sirkumpolar, konstelasi dan zodiak.

III. Sistem Waktu dan Kalendar

1. Waktu Surya,
2. Waktu Sideris,
3. *Julian Date*,
4. Persamaan (perata) waktu,
5. Zona waktu,
6. *Universal Time*,
7. *Local Mean Time*,
8. Perbedaan definisi tahun (kalendar Julian, Gregorian, Hijriah, dan Cina),
9. Konversi dari kalendar Islam: Hisab Urfi ke kalendar Masehi: Gregorian dan sebaliknya.

IV. Mekanika Benda Langit

1. Hukum gravitasi Newton,
2. Hukum Keppler,
3. Limit Roche, *baricenter*,
4. Problem 2-benda, titik Lagrange; pasang surut;
5. Polinom dan teorema Descartes;
6. Orbit dalam ruang.

V. Fenomena Astronomi (Sistem Bumi-Bulan-Matahari)

1. Pasang surut, Musim, Gerhana, Aurora, Meteor shower;
2. Gerhana Bulan dan Matahari: variasi dan perbandingan diameter sudut Bulan dan Matahari, fase Bulan, umbra dan penumbra, klasifikasi gerhana Bulan dan Matahari, musim gerhana: siklus Saros dan Meton.
3. Siklus Gerhana: gerak dan orbit Bulan, siklus Saros, siklus Meton, dan periode Saros.
4. Gerhana dalam kultur manusia: dinamika reaksi masyarakat saat terjadinya gerhana.

5. Equinox, perihelion dan aphelion, eksentrisitas Bumi, periode sideris dan sinodis, inklinasi, dan momentum sudut.
6. Sistem Bumi-Bulan: data fisis Bumi dan Bulan, data orbit Bulan, pusat massa sistem Bumi-Bulan, dan medan potensial Bumi-Bulan.
7. Skala terang sabit Bulan: magnitudo visual, kecerlangan sabit Bulan, kecerlangan permukaan sabit Bulan, skala terang Bumi-Bulan-Matahari, sudut ruang, hubungan antara magnitudo, fase, dan jarak Bumi-Bulan, sudut fase dan elongasi, skala terang *earthshine*.

VI. Matahari

1. Struktur Matahari,
2. Aktivitas permukaan,
3. Rotasi Matahari,
4. Radiasi dan konstanta Matahari,
5. *Solar neutrino*,
6. Relasi Matahari-Bumi,
7. Peran medan magnet,
8. Angin Matahari dan tekanan radiasi,
9. *Heliosphere, magnetosphere*,
10. Bintik Matahari,
11. Rotasi diferensial Matahari,
12. Siklus Matahari.

VII. Tatasurya

1. Sistem Bumi-Bulan, presesi, nutasi, librasi,
2. Pembentukan dan evolusi tata surya, struktur dan komponen tata surya,
3. Struktur dan orbit benda tata surya, perioda sideris dan sinodis, gerak retrograde,

4. Survey tata surya: kategori planet, planet kebumian: kerapatan dan interior, proses di permukaan, planet Jovian, atmosfer planet, benda kecil, dan pembentukan tata surya.
5. Planet Jovian dan satelitnya: karakteristik planet Jovian, atmosfer dan interior Jupiter, satelit Jupiter, cincin Saturnus, atmosfer Saturnus, misi ruang angkasa ke Saturnus, atmosfer Saturnus, satelit Saturnus, misi ruang angkasa ke Uranus, atmosfer dan interior Uranus, cincin Uranus, satelit Uranus, misi ruang angkasa ke Neptunus, atmosfer Neptunus, satelit Neptunus, cincin Neptunus, dan sifat-sifat utama satelit planet Jovian.
6. Planet luar-surya: teknik mencari planet luar-surya.

VIII. Bintang

1. Satuan/unit jarak benda langit: satuan astronomi, tahun cahaya, dan parsek,
2. Skala terang absolut (magnitudo absolut) dan skala terang semu (magnitudo semu).
3. Warna bintang dan temperatur permukaan bintang.
4. Luminositas dan temperatur efektif bintang.
5. Penentuan radius dan massa,
6. Bintang variable, fisis pulsasi,
7. Kesetimbangan bintang, nukleosintesis bintang, transportasi energi, *boundary condition*, atmosfer dan spectrum bintang,
8. Pembentukan bintang, diagram Hertzprung-Russell, bintang pra-deret utama, bintang post-deret utama, supernova, *planetary nebulae* , keadaan akhir bintang,

IX. Sistem Bintang

1. Jenis bintang ganda, penentuan massa sistem bintang ganda, kurva cahaya, kecepatan radial, *interacting binaries*, pergeseran Doppler dalam sistem ganda, sistem ganda pekuliar,
2. Teknik memburu *exoplanet*,
3. Gugus bintang: klasifikasi dan struktur, massa, umur, penentuan luminositas dan jarak.

X. Galaksi Bima Sakti dan Ekstragalaksi

1. Emisi gas hidrogen netral (HI).
2. Molekul hidrogen (H_2) yang di-*tracer* oleh molekul CO.
3. Hidrogen terionisasi (HII), radiasi 21cm, nebula, absorpsi antarbintang,
4. Debu
5. Gugus bola dan gugus terbuka
6. Struktur Bima Sakti: populasi bintang, menentukan umur gugus bintang, menentukan metalisitas bintang, paralaks spektroskopi, *main sequence fitting*, dan RR Lyrae.
7. Komponen Galaksi: *halo*, *bulge*, dan *disk*.
8. Klasifikasi galaksi: morfologi dan warna.
9. Menentukan jarak, massa, dan luminositas galaksi, kurva rotasi galaksi.
10. Galaksi aktif, luminositas Eddington.

XI. Kosmologi

1. Alam semesta mengembang, pergeseran merah, dan hukum Hubble;
2. Model kosmologi standar.
3. Sejarah termal alam semesta.
4. Struktur skala besar alam semesta.
5. Evolusi pertumbuhan struktur besar alam semesta.
6. Gugus galaksi dan interaksi galaksi.
7. Bukti keberadaan Big Bang.
8. Mengukur jarak menggunakan supernova tipe Ia.
9. Evolusi alam semesta.
10. Redshift kosmologi.

XII. Instrumen Astronomi

1. Teleskop dan detektor (CCD, *photometers*, *spectrographs*), magnifikasi, panjang fokus, *aperture syntheis*,
2. Astronomi *multi-wavelength*: observasi radio, *infrared*, *visible*, *x-ray*, efek atmosfer Bumi.
3. Pengenalan cara kerja teleskop-teleskop yang ada di Observatorium Bosscha.

XIII. Matematika

1. Fungsi polinom, eksponensial, logaritmik, rasional, linier;
2. Invers fungsi, geometri ruang, trigonometri,
3. Vektor, matriks, geometri irisan kerucut,

XIV. Fisika

1. Momentum dan tumbukan, rotasi benda tegar,
2. Termodinamik, medan listrik dan magnet,
3. Geometri optik, sifat cahaya (interferensi, difraksi, polarisasi),
4. Teori relativitas,

XV. Statistika

1. Angka penting,
2. Teori probabilitas, fungsi distribusi probabilitas, statistika deskriptif,
3. Teori kesalahan,
4. Regresi linier, interpolasi, ekstrapolasi.

Praktek

I. Pengamatan

a.Pengamatan langsung dengan mata;

b.Pengamatan dengan peta langit dan katalog;

c.Pengamatan dengan teleskop Vixen :

1. Mengukur separasi dan posisi sudut sistem bintang ganda visual (citra tanpa filter). Lakukan pengamatan minimal untuk 3 objek dengan magnitudo ≥ 4.
2. Image stacking RGB untuk objek-objek *deep sky*.

d.Pengamatan dengan teleskop C-8 :

1. Menentukan koefisien ekstingsi dan magnitude bintang di luar atmosfer dengan memonitor cahaya bintang (BVRI) dari meridian ke horizon,
2. Membangun diagram HR dan diagram 2 warna dari fotometri BVRI gugus terbuka,

e.Pengolahan citra.

II. Pengolahan Data

1. Identifikasi sumber error, kalkulasi error, dan estimasi pengaruhnya pada hasil akhir,
2. Ragam plot dengan skala berbeda, logaritmik, polar, transformasi data dan fitting data, metode *least-square*,
3. Dasar analisis statistik data observasi, Rata-rata, standar deviasi, dan *chi square*,

Seleksi Olimpiade Astronomi (OSK, OSP dan OSN)

Ciri-ciri soal Aspek	**SMA**
Recalling	Siswa mampu mengungkapkan kembali apa yang telah dipelajari dan merumuskannya dengan rinci
Motorik	Siswa tanggap dan cepat menjawab pertanyaan dengan rinci dan terukur
Lojik	Siswa dapat menjawab soal yang bersifat terbuka diikuti dengan logika matematis
Kreatif	Siswa mampu berimprovisasi dalam menjawab soal

Sifat Pertanyaan
Terbuka: bertujuan untuk menggali potensi/pengetahuan anak selain yang didapat dari sekolah. Jawaban bersifat jamak
Tertutup: bertujuan untuk mendapatkan penegasan apakah pertanyaan dimengerti dan dapat dijawab dengan baik. Jawaban bersifat unik
OSK(Olimpiade Sains Kabupaten): Multiple Choices
OSP(Olimpiade Sains Provinsi): Multiple Choices+Essays
OSN(Olimpiade Sains Nasional): Multiple Choices+Essays+Pengolahan Data+Observasi

Model soal untuk tiap tahapan olimpiade

No	**Tahapan Olimpiade**	**Multiple Choices**	**Essay**	**Observasi**	**Peng. Data**
1.	Kabupaten (OSK)	Ya	Tidak	Tidak	Tidak
2.	Provinsi (OSP)	Ya	Ya	Tidak	Tidak
3.	Nasional(OSN)	Ya	Ya	Ya	Ya

Syllabus of

International Olympiad on Astronomy and Astrophysics (IOAA)

1 General Notes

1. Extensive contents in basic astronomical concepts are required in theoretical and pratical problems.

2. Basic concepts in physics and mmathematics at high school level are required in solving the problems. Standard solutions should not involves extensive use of calculus and/or the use of complex numbers and/or solving differential equations. However, students would find it useful to be familiar with simple differentiation with respect to single variable and simple integration.

3. Astronomical software packages may be used in practical and observational problems. The contestants will be informed the list of software package to be used at least 3 months in advace. The chosen software packages shoulde be preferably freewares or low-cost ones enabling all countries to obtain them easily for practice purpose. The chosen softwares should preferablu be available on multiple OSs (Windows/Unix/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 theh contestants without previous knowledge of these topics would not be at a disadvantage.

5. Sophisticated practical equipment 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 problemns have to be set in the SI units, whereever applicable. Participants will be expected to mentions, appropriate inits 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.

2 Theoretical Part

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

The following theoretical contents are proposed for the contestants:

2.1 Basics Astrophysics

Contents	Remarks
Celestial Mechanics	Newton's Law of Gravitation, Kepler's Law for circular and non-circular orbits, Roche limit, barycenter, 2-body problem, Lagrange points
Electromagnetic Theory & Quantum Physics	Electromagnetic spectrum, radiation law, blackbody radiation, doppler effect
Thermodynamics	Thermodynamic equilibrium, ideal gas, energy transfer
Spectroscopy and Atomic Physics	Absorption, emission, scattering, spectra of celestial objects, 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)

2.2 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

2.3 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, nutatuin, libration, formation and evolution of solar system (Q), structure and components of 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 trajectorues 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, auroras (Q), meteor showers

2.4 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 variables, physics of pulsation (Q)
Stellar Interior and Atmospheres	Stellar equilibrium, stellar nucleosynthesis, energy transportation (Q), boundary condition, stellar atmospheres and spectra
Stellar Evolution	Stellar formation, Hertzprung-Russell diagram, pre-main sequence stars, post-main sequence stars, supernovae, planetary nebulae, end states of stars

2.5 Stellar Systems

Contents	Remarks
Binary Star Systems	Differe 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	Exoplanet hunting techniques
Star Clusters	Classification and structure, mass, age, luminosity and distance determination
Milky Way Galaxy	Structure and composition, rotation, satellites of Milky Way
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

2.6 Cosmology

Contents	Remarks
Elementary Cosmology	Expanding universe and Hubble's Law, cluster of galaxies, cosmic micorwave background radiation, Big Bang (Q), alternative models of the universe (Q), large scale structure (Q), distance measurement at cosmological scale, cosmological redshift

2.7 Instrumentation

Contents	Remarks
Multi-wavelength Astronomy	Observations in radio, microwave, infrared, visible, ultraviolet, X-ray, gamma-ray, Earth's atmospheric effects
Instrumentation	Telescopes and detectors (e.g. CCD, photometers, spectrographs), magnification, focal length, resolving and light gathering power, geometric model of two element interferometer, aperture sythesis, adaptive optics

3 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.

3.1 Observations

Observations section focuses in contestant's experience in:

1. Naked-eye observations.
2. Usage of sky maps and catalogues.
3. Application of coordinate systems in the sky, magnitude and angular size estimation.
4. Usage if basic astronomical instruments (telescopes and detectors) for observations but sufficient instructuins 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.

3.2 Data Analysis

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 paper with different scales, e.g. polar and logarithmic paper. Transformation of the data to get 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 measureing physical quantities mentioned in Theoretical Section.