AstroChallenge 2024

Attn: HOD Science

Invitation for AstroChallenge 2024

Dear Sir/Ma'am In-Charge

The AstroChallenge 2024 Core Committee cordially invites your school to participate in the 20th Annual Singapore Astronomy Competition, AstroChallenge 2024, which will be held on 1st June, 3rd June, and 8th June 2024.

The AstroChallenge is an annual astronomy competition jointly organised by the Astronomical Societies of the National University of Singapore and Nanyang Technological University. Designed specifically for students in Secondary Schools, Junior Colleges, and Polytechnics, the competition is geared towards cultivating a deeper interest and understanding of astronomy as well as promoting closer inter-school ties by bringing students together through their shared passion for astronomy. Participants can expect a diverse range of questions encompassing both theoretical and practical aspects of astronomy.

In order to aid students in preparation for AstroChallenge, the syllabus has been released and will be enclosed in the appendices. While these guidelines are not exhaustive, it is intended to serve as a useful tool for schools, especially new participants, to determine the scope of AstroChallenge.

Please refer to the Appendix for more information with regards to:

- **Appendix A:** Schedule of events and information on competition rounds
- **Appendix B:** Entry requirements
- **Appendix C:** Registration – Payment & procedure
- **Appendix D:** Syllabus – General guidelines on the scope of AstroChallenge

Students may also refer to our website at https://www.astrochallenge.org, and/or our Facebook page at https://www.facebook.com/astrochallenge/ for more information. Enquiries can be made to astrochallenge@gmail.com.

AstroChallenge 2024

We hope to present a rigorous, challenging, and fun competition for your students to gain exposure and learn more about astronomy! We look forward to seeing you at AstroChallenge 2024!

Sincerely,

Lu Xixun (Ms.)

Chairperson,

AstroChallenge 2024 Core Committee

AstroChallenge 2024

Appendix A

Schedule of events and information on competition rounds

1. Rounds for Pre-event

- *Data Analysis Round* – Teams will answer a data-centric question beforehand. The question and details on the data needed will be emailed to participating schools at a later date. This Round is for teams registering for the **Senior Category only**

- *Project Round* (**Junior and Senior Category)**
    - Teams will prepare a video, poster, and any other deliverables beforehand as an astronomy-themed project

2. Rounds for Days 1 and 2

- *Project Round* (**Junior and Senior Category)**
    - Teams will present their project to judges and/or the public
    - The topics and other details concerning the project will be emailed to participating schools at a later date

- *Observation Round* – Practical Component (**Senior Category only**)
    - It will be an inter-school event, so participating schools will only have to send one team regardless of the number of teams sent for other rounds.
    - Schools will not be allowed to use a computerised scope.
    - Necessary arrangements will be made if the school is unable to send an approved telescope.

- *Individual Round* – MCQ (**Both Categories** - Junior and Senior)
    - Teams from each participating school will solve astronomy questions individually
    - Team members will submit one response per person and each mark will contribute to the team's total marks

- *Team Round* – Data Response Questions (**Both Categories** - Junior and Senior)
    - Teams from each participating school will come together to solve questions regarding astronomy
    - Each participating team will submit one response per team for this round and they will be marked as one team

- *Observation Round* – Theory Component (**Senior Category only**)
    - It will be an inter-school event, so participating schools will only have to send one team regardless of the number of teams sent for other rounds.

- The round will test participants on theoretical aspects of observational astronomy

3. Rounds for Day 3

- *Finals* – There will be final rounds for **both categories**, namely the Junior Category and Senior Category.
  - Qualifying teams will compete against one another in game shows format (e.g., Jeopardy, Guess the Image, etc.)
  - The round will decide the final rankings of the AC2024 winner in both the Junior and Senior Category.

Details of the rounds, and rules and regulations for the competition will be sent in early March via email to the teacher-in-charge and respective team leaders. Please ensure that you will be contactable via email.

AstroChallenge 2024

Appendix B

Entry requirements

1. Schools are free to send in any number of teams per category. You may send up to 5 members per team. It is recommended to send full teams of 5.

- Senior Category: For all Junior Colleges, Polytechnics, and Institutes.

- Junior Category: For all Secondary Schools. Schools with Integrated Programme (IP) may also send their students in the Junior Category if they are in a year system equivalent to Secondary 4 or below, and are 16 years old and below as of 1 Jan 2024.

2. Only one team from each school can qualify for the finals of each category. IP schools can have one team in the Junior Category finals and another team in Senior Category finals.

Appendix C

Registration - Payment & procedure

Date of Registration	2 Members	3 Members	≥ 4 Members
Before 31st March (Early Bird)	S$30	S$50	S$60
31st March to 1st May (Regular)	S$40	S$60	S$70
After 1st May (Late)	S$55	S$75	S$85

1. Payment advice and procedure will be sent, together with the confirmation email, to participants who register successfully. Payment will be made online and should be made within 2 weeks of the confirmation email.

2. Registration will only begin after the information letter is sent out in the first week of March. Registration will be done online through http://www.astrochallenge.org/. Please register before **1st May 2024**.

3. The AstroChallenge Core Committee reserves the right to charge an additional S$15 administrative fee for late registrations and amendments after the registration deadline. Registration fees are **non-refundable**.

AstroChallenge 2024

Appendix D

Syllabus - General guidelines on the scope of AstroChallenge

This syllabus has been compiled as a preparation guide for AstroChallenge. It is the question-masters' utmost wish that the focus of the paper be shifted away from trivia-based learning towards a more conceptual approach focused on understanding and application. By encouraging such an approach, AstroChallenge aims to promote a scientific and logic-based reasoning process that students will not only be able to apply to Astronomy, but also to the major sciences taught in the school's curriculum.

This syllabus may be subjected to minor changes from time to time. The syllabus enclosed below is verified to be correct as of the date of this letter.

Basic Celestial Mechanics

Participants will be required to have a good grasp of geometry and basic trigonometry in the context of astronomy. They are also encouraged to have a good understanding of the physics behind celestial mechanics.

1. Account for the motion of celestial bodies
2. Understand the concept of the celestial sphere, coordinate systems, orbits of planets, and terminology including conjunction, opposition, elongation, aphelion, perihelion
3. Be familiar with Earth's orbital motion; the difference between solar and sidereal day, tropical and sidereal year; and the analemma
4. Relate Earth's axial tilt and precession with basic astronomical timekeeping.
5. Be familiar with the basis of lunar and solar calendars
6. Understand the occurrence of transits, lunar and solar eclipses

History of Astronomy

Participants are expected to understand the significance of astronomical discoveries in the context of their respective topics. It is also highly encouraged that participants learn how competing theories in the past are disproved or reinforced. Participants will not be specifically tested on the names of astronomers or physicists.

The Solar System and extrasolar systems

Participants are not required to know the specific names of asteroids, moons, or Kuiper-belt objects. Memorisation of physical data as well as specific names of geographical features pertaining to the Sun and planets is not required.

1. Understand the formation of planets, namely the nebular hypothesis, protoplanetary disks, accretion mechanisms, planetary migrations and the Nice Model
2. Recall distinct features and geology of Solar System planets and their respective major natural satellites along with theories regarding their formation and/or mechanism
3. Compare and contrast various theories of the Moon's formation
4. Account for the formation, decay and composition of planetary rings
5. Be familiar with Roche limit and resonance orbits in relation to orbital stability, rings and asteroid belt formation
6. Describe the location of the Asteroid belt, Trojan Asteroids, Kuiper Belt, Oort Cloud and the properties of its members as well as theories of formation
7. Know Kepler's Laws of Planetary Motion
8. Be familiar with associated theories related to the formation of comets
9. Be aware of hypothetical theories of planets and other objects - Vulcan, Nemesis, Planet X, as well as tests of these theories.
10. Understand the methods of detecting and studying exoplanets

The Sun, the Stars and Stellar Evolution

A good understanding of thermodynamics and the ideal gas law is encouraged here.

1. Know what type of star the sun actually is
2. Recall physical properties of the Sun and the solar interior
3. Understand the solar cycle, sunspots, solar flares and coronal mass ejections
4. Understand the solar neutrino problem and its resolution
5. Understand the process of stellar nucleosynthesis and dominant pathways
6. Understand the mechanism of the proton-proton chain, CNO cycle and the triple-alpha process
7. Understand the concepts of magnitude, luminosity and brightness in relation to celestial objects
8. Be familiar with blackbody radiation in relation to physical properties of stars, including temperature, mass, and radius
9. Know the significance behind the Hertzsprung-Russell Diagram as well as how it is used and constructed in practice
10. Describe interstellar matter and different types of nebulae
11. Account for the extinction and reddening of light
12. Know the mechanism of stellar birth and evolution
13. Know the formation of Star Clusters, and illustrate Open clusters and Globular Clusters on HR diagrams
14. Understand the concept of metallicity, with relation to stellar generations (Pop I, Pop II and Pop III stars)

15. Recall the various types of variable stars and their mechanism of pulsation, most notably Cepheids
16. Know the classification of binary stars and their light curves
17. Understand the processes occurring in mass transfer binaries and how the Roche limit and Roche Lobe applies
18. Account for stellar explosions: Planetary nebulae and Supernovae (Ia and II)
19. Be familiar with accretion disk mechanisms
20. Describe the mechanism and evolution of pulsars
21. Account for Gamma-ray bursts and X-ray bursts
22. Describe the structure of black holes
23. Recall the no-hair theorem coined by John Wheeler

Relativity

Questions pertaining to relativity will only be asked in relation to an astronomical setting. General Relativity will only be tested in a qualitative sense while adequate formulas will be provided for Special Relativity

1. Recall the postulates of General Relativity and Special Relativity
2. Understand the consequences of General Relativity and Special Relativity, and how they differ from classical mechanics.
3. Perform calculations using the Lorentz factor and transformations

Observational Techniques in Astronomy and Empirical Applications

Participants are not required to memorise specific names, or dates of manned or unmanned spacecraft. They should understand the use of the following:

1. Understand the construction of the cosmic distance ladder scale – derivation, theoretical foundations as well as common standard candles (Type Ia, Cepheids and RR Lyrae stars)
2. Know how to find distances to stars and galaxies through techniques such as spectroscopic parallax, main sequence fitting and other given distance relations
3. Understand how to measure the Astronomical Unit and distances within the Solar system
4. Adaptive and corrective optics
5. Radio telescopes and the use of interferometry
6. Advanced telescopes operating in the entire electromagnetic spectrum
7. Understand the reasons for the global distribution of large professional telescopes

Galaxies

1. Recall the size and structure of the Milky Way, such as distribution of star clusters
2. Describe the density wave model of spiral arms and how it results in stellar formation
3. Account for the rotation curve of galaxies via the idea of dark matter
4. Recall the Shapley-Curtis Debate and differing arguments from each side
5. Give a brief account of Hubble's classification in his tuning fork diagram as well as various types of galaxies.
6. Understand the processes behind galaxy mergers, collisions, and interactions, as well as how this affects galaxy evolution.
7. Understand the mechanism of radio galaxies with active galactic nuclei.
8. Account for radio lobes and galactic jets with superluminal motion
9. Distinguish between Seyfert galaxies, quasars and blazars
10. Understand the difference between hot dark matter and cold dark matter, and their significance in the formation of galaxies
11. Be familiar with galaxy clusters, Superclusters and cosmic voids

Cosmology

Participants are not required to focus on speculative theories such as Parallel Universes or the Oscillatory Universe Model. Topics that are linked closely with particle physics such as The Standard Model or string theory will not be covered without additional help as well.

1. Compare the merits and demerits of Big Bang Theory and Steady State Theory
2. Have an understanding of the fundamental forces of the universe and their roles in the Big Bang Theory.
3. Understand Olbers' Paradox and its resolution
4. Appreciate the significance of the cosmological principle
5. Understand that the fate of the Universe depends on critical density and entropy
6. Appreciate the importance of the cosmic microwave background radiation
7. Understand the theory of inflation and why it was required
8. Resolve the flatness problem and horizon problem
9. Appreciate the cosmological constant and its relation to dark energy
10. Describe and differentiate potential explanations for dark matter
11. Appreciate the means of detecting gravitational waves

Astrobiology

Participants are encouraged to have a good biological background in regards with this topic

and should understand the conditions for life in relation to an astronomical setting. Memorising of specific exoplanets are not required.

1. Understand why Earth is the most suitable planet for carbon-based lifeforms in the solar system
2. Know the rationale behind other solar system objects that are proposed to harbour life
3. Appreciate the different theories for the origin of life on Earth
4. Understand the risks due to near-earth asteroids and the need for planetary defence
5. Appreciate the importance of extra-terrestrial organic, Carbon-based compounds as precursors for life
6. Appreciate Drake's equation, Rare Earth Hypothesis and their significance in relation to extra-terrestrial life (memorisation of formulae is not required)
7. Understand the methods of detecting and studying exoplanets (moved from The Solar System and extrasolar systems)
8. Know the importance of liquid water as a chemical solvent and its status as a sought-after criterion in the search for exoplanets
9. Integrate cross-topic knowledge (spectroscopy) and their applications for studying exoplanets.

Practical Astronomy and the Night Sky

To familiarise themselves with the night sky, participants are encouraged to stargaze often. Additionally, participants should be familiar with any and all equipment as well as common terms used. Handling and Basic Maintenance skills for telescopes are required during the Observation Round for seniors.

Participants are not expected to know the exact market price of different telescopes. Participants are also not required to remember any deep sky objects beyond the following 4 categories:

I *Messier Catalogue Objects*

II *Caldwell Catalogue Objects*

III *Popularly Named DSOs*

IV *Names of Planets, Pluto as well as Ceres and other popular Kuiper Belt Objects*

For the avoidance of doubt, for categories III and IV above, what is popular cannot be exhaustively listed. In cases of dispute arising, the AstroChallenge Questionmasters' decision will be final.

1. Discuss the designs, merits and demerits of various telescope designs and mounts
2. Describe the property of images formed through optical elements of an astronomical set-up

3. Understand that light gathering power is dependent on aperture, not magnification; calculate resolving power using Rayleigh criterion and Dawes' limit
4. Show a basic understanding of astrophotography and associated techniques
5. Understand any and all terms or abbreviations relating to observational astronomy including but not limited to the OTA, Field Stop, Field of View etc.
6. Appreciate the use of all telescope accessories including but not limited to the mount, the polar scope, the finder scope, the telrad etc.
7. Demonstrate an understanding of the speed of a telescope
8. Understand factors that determine magnification
9. Describe how certain optical aberrations could be minimized or prevented
10. Be familiar with common naked-eye, binocular or telescope targets often seen from Singapore throughout the year
11. Be familiar with the major constellations for the different seasons and its bright stars
12. Know common procedures for the maintenance and use of astronomical equipment
13. Be familiar with the use of star-charts/planispheres, coordinate terminology as well as how different telescope mounts are to be operated
14. The making and reading of the following:
    a. Starcharts;
    b. Observation Plans;
    c. DSO Table;
    d. Basic Astrophotography and Pencil Sketches;
    e. Explanations for equipment relating to Astronomy; and
    f. Instructions for the operation of any equipment relating to Astronomy