Astronomy Olympiads

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1 Introduction

Hello, my name is Akarsh Raj Sahay, and I represented India in IOAA 2023. I am creating this document to help others who want to get started with astronomy at the school level and/or prepare for the Astronomy Olympiad. This document contains advice on studying for the Astronomy Olympiad based on the stages of the Indian Astronomy Olympiad Programme. The material of each preceding stage can be considered a prerequisite for the next. Even if someone wants to learn astronomy just for the sake of it, following the order in which the topics are mentioned will be more beneficial than studying haphazardly.

2 Stages

Stage 1: NSEA

Before anything else, it is extremely important to have a good grasp of physics and mathematics (preferably both 11th and 12th-grade level) in good detail. I am mentioning some of the most important physics topics that a lot of introductory astronomy is concerned with, but this list should not be considered exhaustive:

- Gravitation
- Radiation and heat transfer
- Geometric and wave optics
- Fluid statics and dynamics
- Thermodynamics of ideal gases
- Atomic structure

In NSEA, one can usually qualify based on JEE Physics and Maths alone. Studying astronomy specifically for NSEA may prove to be a futile exercise, as a relatively advanced level of understanding is required to solve most of the astronomy questions. Even if you have the time, it would be more beneficial to strengthen your grasp of physics and mathematics, as that will help both in this

exam and later when you begin studying astronomy and astrophysics. Solving previous years' NSEA papers (available on the IAPT website) will also be of great help.

Stage 2: INAO

Even at this stage, it is crucial to be proficient in JEE Physics and Maths, as they constitute most of the paper, and many students can qualify by answering only those questions. However, it would be beneficial to start studying astronomy now.

Firstly, watch this YouTube series. It is a great quantitative introduction to the topics you are expected to know for the Olympiad.

You may also check out this channel, run by the people at HBCSE (whom you will meet if you go to the camp). This has broader coverage of relevant topics, but I haven't watched all the videos, so I can't comment on their usefulness.

- Now that you have a basic idea, you can start studying from books. I recommend starting with **Astronomy: Principles and Practice** by Roy and Clarke. The first 15 or so chapters are important and well written. They even include some exercises. If you find something difficult (such as Chapters 10 and 11), you may skip it initially. You can also skip spherical trigonometry, as it has never been tested in the INAO before.

- Roy and Clarke covers only a limited range of topics. You can begin studying additional books (not entirely—mostly the first few chapters):

  - **Fundamental Astronomy** – Karttunen et al.
  - **The Universe** – Freedman and Kaufmann (This has a particularly nice discussion on eclipses.)

It is extremely useful to solve past INAO papers (you can also try some INPhO papers) to get an idea of the type and range of questions asked. If you encounter something unfamiliar, look it up in the books mentioned above or online. Past papers are the greatest resource.

As for night sky observation questions, at this stage I would recommend learning the shapes of constellations in the zodiac belt and some famous constellations (Ursa Major, Orion, Pegasus, Hercules, Bootes, etc.—this list is not exhaustive). If you have the time, you can eventually memorize the entire sky. More on this in the next section.

Stage 3: OCSC

Real astronomy begins here. This stage tests you on four components:

Theory

Focus on this part the most while preparing, as the others are mostly learned during the camp itself. It will be difficult to master theory you have just encountered at the camp.

Use the official IOAA syllabus as a guide for the topics and study them from the books mentioned below. You will find all the topics covered in these books.

In addition to the books mentioned earlier, study these as well:

- **An Introduction to Modern Astrophysics** by Carroll and Ostlie
- **Introduction to Cosmology** by Ryden
- At this point, you must become proficient in spherical trigonometry (it is tested extensively at the camp). You can use **Astronomy Problems** by Vorontsov-Velyaminov as a problem source.
- **A Problem Book in Astronomy and Astrophysics** by Aniket Sule — a compilation of old IOAA problems with excellent solutions. This is a must-have book.

JEE Mathematics topics such as probability and statistics, vectors, 3D geometry, and coordinate geometry will be useful. JEE Physics is a prerequisite for studying any of the books mentioned above.

You should also solve USAAAO and SAO papers (these are the national astronomy Olympiads of the USA and Singapore, respectively). The questions are excellent practice and come with solutions.

Data Analysis (DA)

You will be expected to draw a lot of graphs (often with many data points). Be nimble with this process and practice enough to become fast and accurate. To get an idea of the kinds of problems asked, look at old IOAA DA papers and the SAO DA section. You will be given ample practice and instructions on graph plotting at the camp.

Night Sky Observation

This is the most overwhelming (and initially annoying) part, as it involves a lot of memorization—but as you get familiar with it, it becomes one of the most fun components.

Install the software **Stellarium** on your PC and phone. It is essentially a simulation of the night sky and can be used to learn constellations and star names. You should be familiar with the shapes (with and without constellation lines; you can use Anki flashcards for this) of almost all northern and equatorial constellations (and southern ones too, if you're brave). Learn the names and locations of their bright stars. Some people also memorize which star is the α, β, γ, etc., star of the constellation.

You can practice star maps by taking screenshots of sections of the Stellarium sky, inverting the colors (so your printer doesn't waste ink printing a black background), and printing them. SAO papers also include similar problems and are worth trying.

If your skies are clear, go outside at night and use Stellarium to identify the stars you see. Learn their relative positions, orientation, and brightness, and simply get acquainted with the night sky.

Next come the Messier objects. Try to learn the positions of the famous ones (just Google "famous Messier objects" and learn whatever you can). Whenever you are learning about the stars in constellations, check whether they contain any Messier objects and remember their positions and identification numbers.

Telescope

Before the camp starts, very few people have even properly used a telescope, so don't worry if you haven't. This is one of the skills you mostly learn during the camp. Make the most of your telescope time, and learn by observing the teachers and your peers. It's also a great time to learn constellations and stars, as you will be under open skies.

If you happen to own or can rent a telescope (usually 6-inch or 8-inch Newtonian reflectors or Dobsonians, similar to those used at the camp), get some practice mounting the telescope, aligning the finder scope, and pointing it at stars. Be patient and observant—it's difficult at first, but almost everyone manages to do it by the end.

Stage 4: IOAA

The Astronomy Cell at HBCSE is excellent and will provide you with additional material to solve if you make it to the team. IOAA past papers are extremely important. At this stage, you will likely have enough experience to know what works best for you.