Astronomy writing with

LaTeX and AI/LLMs

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Abstract

As an astronomy educator, researcher, and outreach professional, I have been deeply engaged with astronomy literature for a long time. During my high school years, as I was learning the foundational concepts of astronomy, I came across countless notes written in LaTeX, each with unique styles of writing and presenting various concepts. Later, as I took on the role of team leader for Bangladesh's International Olympiad participants, I created numerous notes and problems using LaTeX to aid in preparation and question design. This eventually culminated in the writing of a textbook in Bengali. Another key experience came from participating in eight International Board Meetings (IBMs) of the IOAA, where leaders from 50 countries debated the nuances of writing, formatting, and symbolizing astronomical concepts. These discussions highlighted the need for a unified guide on writing astronomy with LaTeX. Recognizing this gap, I decided to create such a document—here it is. This document provides concise, practical rules and a template for writing self-contained, unambiguous, and well-formatted astronomy problems appropriate for national and international olympiads. It includes recommended LaTeX conventions, marking structure, AI/LLM usage checklist, and an example problem template that follows IOAA style conventions.

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1 Writing as Astronomer/Astronomy Educator

1.1 Definitions

Definition (**Self-containment**)**.** A problem is *self-contained* if a solver with a standard high school or undergraduate physics/astronomy background (but possibly different subfield/olympiads i.e., IPhO/IJSO/IESO) can derive every step of the solution using only:

- The information explicitly provided in the problem statement, and
- Textbook-level knowledge and standard constants (e.g. Newton's gravitational constant G, speed of light c), when those constants are either given or their use is standard and explicitly permitted.

A self-contained prompt therefore requires that:

a) Every symbol appearing in the question and in subparts must be defined the first time it appears (units and numerical values included). For example: "Let $M_\star$ denote the stellar mass; take $M_\star = 1.2\,\mathrm{M}_\odot$."
b) Any observational or instrumental parameters (exposure time, filter central wavelength, telescope diameter, quantum efficiency, background sky brightness, etc.) needed to compute a numerical answer must be provided or the statement must explicitly instruct the solver to adopt a standard assumption and give its numerical value.
c) If a known physical constant is used, either give its numerical value in the problem statement (preferred) or explicitly state that the solver may use accepted CODATA values, table of constant [TOC] values and list which ones are allowed.
d) The problem explicitly states the approximation regime (e.g. "assume geometric optics", "neglect atmospheric refraction", "use non-relativistic mechanics"), or else must be exact within textbook methods.

Definition (**Unambiguity**)**.** A prompt is *unambiguous* if every expert reader interprets the task in the same way and that interpretation leads to a unique final answer (up to trivial algebraic rearrangements). Practically, ensure that:

a) There is no defensible alternative interpretation of a phrase or symbol that changes the final numerical result or the method required.
b) The statement forbids or explicitly allows common approximations when those approximations alter the result (for example: "Neglect limb darkening" or "Include limb darkening using model X with parameter values ...").
c) The final answer is fully specified: give required units and a directive on the form of the answer (e.g. numerical value, symbolic expression, order-of-magnitude estimate) and, for numerical parts, the number of significant figures required.
d) If vector or sign conventions matter (e.g. direction of positive angle, right-hand-rule for cross products, definition of position angle), state them explicitly.
e) Avoid trick-question phrasing that relies on linguistic ambiguity; olympiad problems should test physics and reasoning, not reading-comprehension traps.

1.2 Problem structure and marking

Olympiad problems should be modular and clearly marked. For IOAA style include marks at the end of each subpart using the following convention:

Example: "(a) Show that ... [4 Marks]"

For numerical subparts, always add a line stating the significant-figure requirement. Example:

"Round your answer to **3 significant figures.**"

Be explicit about whether intermediate rounding is permitted and whether answers must carry uncertainties.

1.3 Using AI / LLMs responsibly

When using AI to draft problems and solutions, follow this checklist:

1. Specify the exact output format you want the model to produce (problem text, latex source, solution steps, numerical answers, mark allocation, hints). Include example tokens if necessary.
2. Run the problem through at least two independent models (e.g. ChatGPT, Claude, Gemini) and compare answers for consistency at the required significant-figure level.
3. If model outputs differ, inspect the question for hidden assumptions or ambiguities and correct them; rerun until all models (and a human reviewer) agree on the canonical solution.
4. Cross-check numerical constants and unit conversions in the solution; do not trust model-provided constants without verification.
5. For multi-part or long solutions, provide a compact, rigorous solution in LaTeX for graders to use; keep informal model prose separate from the official solution.

1.4 Creativity and originality

Good Olympiad problems usually combine standard physics with a novel twist. Recommendations:

- Use realistic but simplified astronomical contexts (observational setups, stellar models, orbital geometry) to give authenticity.
- Borrow pedagogical motifs from past IOAAs but change parameters, add a second constraint, or combine subfields (e.g., dynamics + radiative transfer) to make a fresh problem.
- Avoid copying published problem texts; if inspired by a past problem, explicitly note the inspiration for internal review.
- If inspired or taken any manner of data from a published paper, always quote the source in the question statement, the problem title, or the arXiv code should be given.

1.5 Template: problem + solution outline

Problem template (IOAA style)

(a) **Statement:** Present a short physical setup with numeric values. Define all symbols. [Marks]

(b) For each calculational subpart, include: required units, rounding instructions, and expected form of the answer. Example: "Compute the stellar luminosity L in watts. Round your answer to **2 significant figures**." [Marks]

(c) **Final line:** "For numerical parts round your answers to the number of significant figures specified in each subpart."

Example. The star Dschubba (δ Sco) has a parallax $p = 8\,\text{mas}$. Assuming it is a spherical blackbody with radius $R = 7.5\,R_\odot$ and surface temperature $T = 28,000\,\text{K}$, compute Dschubba's

a. Luminosity in Wm^{-2}, and $L_\odot$ [3sf] [2]
b. Apparent magnitude; [3sf] [2]
c. Absolute magnitude; [3sf] [2]
d. Distance modulus; [2sf] [2]
e. Peak wavelength λ_{max}; [4sf] [2]
f. If we get Δf more brightness from the Star with $\Delta f \ll f$. What is the difference between past and present magnitudes? [4sf] [2]

Solution outline Provide a clean derivation with numbered steps. List approximations explicitly and show final numerical values with units and uncertainties if required.

1.6 Submission and review checklist

Before submitting a problem to the national committee, verify:

- The problem is self-contained and unambiguous (run the checklist in Section 2).
- All symbols and constants are defined; units are consistent.
- AI outputs were cross-checked and any model disagreements resolved.
- Marking scheme is clear and divisible into small, testable steps.

2 LaTeX and notation conventions

Astronomy LaTeX typeset has its own rules and regulations. As we're doing academic work in Astronomy we should follow the conventions set by Astronomers. The basic typeset mistake and how to solve it can be found here. Some Astronomical writing Tips.

2.1 Useful Package

Here are some useful packages that you should install for Astronomical writings

```
\usepackage{mathabx} % Provides Astrological symbols
\usepackage[super]{nth} % Provides nth power superscript
\underpackage{mathtools} % Provides box environment inside align
\usepackage{pdfpages} % For inserting and addings pdfs
\usepackage{cancel} % For cencelling equations
\usepackage{mhchem} % checm equations
\usepackage{bm} % bold math
```

2.2 General Mistakes or Your working hard

Tip 1

The most common problem I've seen people hassle with is how to align/center your equations: You can write like this

```
    $$\cos a= \cos b \cos c+ \sin b \sin c \cdot \cos A$$
```

Which produces

$$\cos a = \cos b \cos c + \sin b \sin c \cdot \cos A$$

Double $$ sign enclosing will add extra spacing before and after the equation, but an easy way to do it is

```
\[\cos a= \cos b \cos c+ \sin b \sin c \cdot \cos A\]
```

$$\cos a = \cos b \cos c + \sin b \sin c \cdot \cos A$$

Tip 2

When we have multiple lines of equation instead of writing like this

```
    $$\cos a= \cos b \cos c+ \sin b \sin c \cdot \cos A$$
    $$\cos \zeta =\sin\delta \sin\phi +\cos\delta \cos\phi\cdot \cos H$$
```

Which produces

$$\cos a = \cos b \cos c + \sin b \sin c \cdot \cos A$$

$$\cos \zeta = \sin \delta \sin \phi + \cos \delta \cos \phi \cdot \cos H$$

We should simply use `\begin{gather*}` function

```
\begin{gather*}
   \cos a= \cos b \cos c+ \sin b \sin c \cdot \cos A\\
   \cos \zeta =\sin\delta \sin\phi +\cos\delta \cos\phi\cdot \cos H
\end{gather*}
```

Output:

$$\cos a = \cos b \cos c + \sin b \sin c \cdot \cos A$$
$$\cos \zeta = \sin \delta \sin \phi + \cos \delta \cos \phi \cdot \cos H$$

Tip 3

Instead of using `\Rightarrow` in equation array use `\implies` or `\implied by`

```
\[\tan\theta = \frac{BT}{SB} \Rightarrow \phi= \theta= \arctan  \frac{BT}{SB}\]
```

Which produces

$$\tan\theta = \frac{BT}{SB} \Rightarrow \phi= \theta= \arctan \frac{BT}{SB}$$

```
\[\tan \theta=\frac{BT}{SB} \implies \phi= \theta= \arctan \frac{BT}{SB}\]
```

Output:

$$\tan \theta=\frac{BT}{SB} \implies \phi= \theta= \arctan \frac{BT}{SB}$$

Tip 4

Instead of using `<<` for **greater than** use `\ll` and for less than `\gg`

```
\[\frac{h}{R}<< 1\]
```

Which produces

$$\frac{h}{R}<< 1$$

```
\[\frac{h}{R}\ll 1\]
```

Output:

$$\frac{h}{R}\ll 1$$

Tip 5

While writing step-by-step solutions/explaning equations you might need to box the final line or the answer part which is a norm. You can do this inside `align` or gather. Depending on the situation,

Using the gather, you can write

```
\begin{gather*}
i=\cos^{-1}\left(\frac{R_\odot}{0.5\; \rm AU}\right)\\
=\cos^{-1}\left(\frac{6.96\times 10^8}{0.5\times 1.5\times 10^{11}}\right)\\
\boxed{i=89.47^\circ}
\end{gather*}
```

Which produces

$$\begin{gathered}i=\cos^{-1}\left(\frac{R_\odot}{0.5\; \rm AU}\right)\\=\cos^{-1}\left(\frac{6.96\times 10^8}{0.5\times 1.5\times 10^{11}}\right)\\\boxed{i=89.47^\circ}\end{gathered}$$

These equations should be aligned for aesthetics reasons, but regular `unserpackages` doesn't support $\boxed{x}$ and `align*` at the same time.

Solution is you install `mathtools` package, and inside align write `Aboxed`

```
\begin{align*}
i&=\cos^{-1}\left(\frac{R_\odot}{0.5\; \rm AU}\right)\\
&=\cos^{-1}\left(\frac{6.96\times 10^8}{0.5\times 1.5\times 10^{11}}\right)\\
\Aboxed{i&=89.47^\circ}
\end{align*}
```

$$\begin{aligned}i&=\cos^{-1}\left(\frac{R_\odot}{0.5\; \rm AU}\right)\\&=\cos^{-1}\left(\frac{6.96\times 10^8}{0.5\times 1.5\times 10^{11}}\right)\\\boxed{i=89.47^\circ}\end{aligned}$$

2.3 Writing Units

- Use proper Astronomical/Astrological symbols as needed. For example: Temperature of a Star or Sun ~~T_s~~, ~~T_{sun}~~ instead $T_\star$, $T_\odot$ $\surd$
- One common mistake people make is leaving the Units in *italic* like kg. But all the units MUST be in normal text like **kg** but if you're using Astronomical units like $m_\odot$, $R_\oplus$ it's ok to keep them italic. Units which can be abbreviated should not be italic **parsecs** → ~~pc~~ but **pc** $\surd$

Use this macros in your preamble to make life easy!

```
\def\ep{\epsilon}
\def\av#1{\langle#1\rangle}
\def\cm{{\rm \, cm}}
\def\mm{{\rm \, mm}}
\def\s{{\rm \, s}}
\def\erg{{\rm \, erg}}
\def\K{{\rm \, K}}
\def\g{{\rm \, g}}
\def\kg{{\rm \, kg}}
\def\km{{\rm \, km}}
\def\dyne{{\rm \, dyne}}
\def\Hz{{\, \rm Hz}}
\def\m{{\rm \, m}}
\def\asec{^{\prime\prime}}
```

- `\ep`: Defines `\ep` as ϵ, commonly used to represent a small quantity or emissivity.
- `\av{}`: Defines `\av{X}` to produce $\langle X \rangle$, representing an average or expectation value.
- `\Msun`: Defines `\Msun` as $M_\odot$, the solar mass, a standard astrophysical unit.
- `\Rsun`: Defines `\Rsun` as $R_\odot$, the solar radius.
- `\cm`: Defines `\cm` as cm, a unit of length in the CGS system.
- `\mm`: Defines `\mm` as mm, a smaller unit of length.
- `\s`: Defines `\s` as s, the unit of time (seconds).
- `\erg`: Defines `\erg` as erg, a unit of energy in the CGS system.
- `\K`: Defines `\K` as K, the unit of temperature in Kelvin.
- `\g`: Defines `\g` as g, the unit of mass in grams.
- `\kg`: Defines `\kg` as kg, the unit of mass in kilograms.
- `\km`: Defines `\km` as km, the unit of distance in kilometers.
- `\dyne`: Defines `\dyne` as dyne, a unit of force in the CGS system.
- `\Hz`: Defines `\Hz` as Hz, the unit of frequency.
- `\m`: Defines `\m` as m, the unit of distance in meters.
- `\asec`: Defines `\asec` as $''$, representing arcseconds, commonly used in astronomy.

Astrophysical Quantities

- The mass of the Sun is represented as `\Msun`, which outputs: $M_\odot$.
- The radius of a star can be written as `2\Rsun`, producing: $2\,R_\odot$.
- A distance of 100 cm is written as `100\cm`, resulting in: $100\,{\rm cm}$.

Physics and Astronomy

- A star's average temperature: `\av{T} = 6000\K` outputs: $\langle T \rangle = 6000\,\mathrm{K}$.
- The angular size of a celestial object: `0.3\asec` outputs: $0.3''$.
- Force acting on a body: `3\dyne` produces: 3 dyne.

```
\newcommand*{\jam}{\ensuremath{^{j}}}
\newcommand*{\h}{\ensuremath{^{h}}}
\newcommand*{\um}{\ensuremath{^{m}}}
\newcommand*{\us}{\ensuremath{^{s}}}
```

Usage:

- ^{j}: Superscript `j`, often used for indices or specific notations.
- ^{h}: Superscript `h`, used for hours.
- ^{m}: Superscript `um`, used for minutes.
- ^{s}: Superscript `us`, used for seconds.

Example:

- 10^h represents 10 hours.
- 15^m represents 15 minutes.
- 20^s represents 20 seconds.

Time Superscripts

These macros are for typesetting angles in degrees, arcminutes, and arcseconds.

```
\newcommand*{\de}{\ensuremath{^{\circ}}}
\newcommand*{\am}{'}
\newcommand*{\as}{''}
```

Usage:

- $^\circ$: Superscript degree symbol ($^\circ$).
- `'`: Prime symbol for arcminutes.
- `''`: Double prime symbol for arcseconds.

Example:

- 45° represents 45 degrees.
- $30'$ represents 30 arcminutes.
- $10''$ represents 10 arcseconds.

2.4 Writing Notation

Table 1: Greek Symbols used in Astronomy

α	Alpha	Right Ascension	ω	omega	Angular Speed, Argument of Periapsis
β	Beta	Ecliptic latitude, Speed as a fraction of light	ψ	psi	Wave function
γ	Gamma	Adiabatic Index, Stellar System (when used for velocity)	τ	Tau	Timescale, Half-life, Optical Depth
δ	delta	Declination, Small Change, Transit Depth	ϕ	Phi	Phase, Latitude, Azimuthal coordinate
ε	varepsilon	Emissivity	φ	varphi	Elongation
η	Eta	Efficiency, Mass fraction			
θ	theta	Arbitrary angle	Λ	Lambda	Cosmological Constant
κ	Kappa	Opacity	Σ	Sigma	Summation, Surface Brightness
λ	lambda	Wavelength, Ecliptic longitude, Length scale	Φ	Phi	Phase, Gravitational Potential, Photon Flux
μ	Mu	Distance Modulus (μ_d), Mean Molecular weight, Surface magnitude, Proper motion, Reduced Mass	Ω	Omega	Angular Speed, Density parameter, Solid angle, Longitude of ascending node
ν	Nu	Frequency, Neutrino	Π	Pi	Product, (Variable star) period
π	pi	3.14... Parallax angle [ϖ]	Ψ	Psi	Wave function, Phase angle
ρ	Rho	Mass density, Position angular distance	Δ	Delta	Change
σ	sigma	Stefan-Boltzmann constant, Cross section, Standard Deviation, Velocity Dispersion			

2.5 Renewcommands

```
% Define macros
\newcommand{\msun}{\ensuremath{M_\odot}}
\newcommand{\rsun}{\ensuremath{R_\odot}}
\newcommand{\lsun}{\ensuremath{L_\odot}}
\newcommand{\mearth}{\ensuremath{M_\oplus}}
\newcommand{\rearth}{\ensuremath{R_\oplus}}
\newcommand{\dearth}{\ensuremath{d_\oplus}}
\newcommand{\aearth}{\ensuremath{a_\oplus}}
\newcommand{\teff}{\ensuremath{T_\mathrm{eff}}}
\newcommand{\kB}{\ensuremath{k_\text{B}}}
\newcommand{\NA}{\ensuremath{N_\text{A}}}
\newcommand{\Fsup}{\ensuremath{F_\text{sup}}}
\newcommand{\dsup}{\ensuremath{d_\text{sup}}}
\newcommand{\thetasub}[1]{\ensuremath{\theta_{\text{#1}}}}
\newcommand{\mangle}[1]{\ensuremath{\measuredangle #1}}
\newcommand{\me}{\mathrm{e}}
\newcommand{\mi}{\mathrm{i}}
\newcommand{\diff}{\mathrm{d}}
\newcommand{\arc}[1]{{%
  \setbox9=\hbox{#1}%
  \ooalign{\resizebox{\wd9}{\height}{\texttoptiebar{\phantom{A}}}\cr#1}}}
```

Solar and Earth-related Quantities

- **\msun**: Represents the solar mass, $\mathrm{M}_\odot$. Example: $M_\odot = 1.989 \times 10^{30}\,\mathrm{kg}$.
- **\rsun**: Represents the solar radius, $R_\odot$. Example: $R_\odot = 6.96 \times 10^{8}\,\mathrm{m}$.
- **\mearth**: Represents the Earth's mass, $M_\oplus$. Example: $M_\oplus = 5.97 \times 10^{24}\,\mathrm{kg}$.
- **\rearth**: Represents the Earth's semi-major axis, $a_\oplus$. Example: $a_\oplus \approx 1\,\mathrm{AU}$.

Physical Constants and Quantities

- **\teff**: Represents the effective temperature, T_eff. Example: $T_\mathrm{eff} = 5778\,\mathrm{K}$.
- **\kB**: Boltzmann constant, k_B. Example: $k_\mathrm{B} = 1.38 \times 10^{-23}\,\mathrm{J/K}$.
- **\NA**: Avogadro number, N_A. Example: $N_\mathrm{A} = 6.022 \times 10^{23}\,\mathrm{mol}^{-1}$.

Miscellaneous Symbols

- **\thetasub**: Custom subscript for θ, e.g., θ_max produces θ_max.
- **\mangle**: Angle symbol using $\measuredangle$. Example: $\measuredangle ABC$ represents $\measuredangle ABC$.
- **\diff**: Upright differential operator, d. Example: $\int_a^b f(x)\,\mathrm{d}x$.

Mathematical Operations and Constants

- **\me**: Represents Euler's number, e. Example: e^x.
- **\mi**: Represents the imaginary unit, i. Example: $\mathrm{i}^2 = -1$.