Astronomy Olympiad Errata

Similarly to the Physics Errata file, here I list all the errors in Astronomy Olympiad solutions that I am aware of. Very often students think they've a made a mistake, while the issue is actually in the original solution. My overall impression is that the quality standards in Astronomy Olympiads are lower than in Physics, so there should be a lot more errors out there apart from those that are already on the list. Still, I hope that this file will be somewhat helpful when preparing at home.

All problems and solutions can be found in my archives.

IOAA

Unfortunately, I last went through the IOAA problems years ago. However, I do know that they're chock-full of errors, so I expect this section to fill up very soon!

(1) **2017 T10D** For some reason, it seems that they want an exact answer. In that case, you should get 6505 rather than 6589.

(2) **2018 T11H** This subpart is pointless – there's virtually no chance for two lines in space to intersect.

(3) **2019 T6C** This is extremely sensitive to the approximations you use. If you assume that the elevation difference is $2\varepsilon = 47^\circ$ rather than the arbitrary 45°, you'll get an equation with no real roots.

(4) **2019 T14B** For concreteness, assume the sides of the CCD chip are aligned parallel to the α and δ directions.

(5) **2019 T14B** There are several errors in how they find the angular velocity of the satellite in the telescope's field of view. After some spherical trigonometry, you can find that the satellite's velocity vector makes an angle $i' = 60.7^\circ$ with the equatorial plate. Hence, the velocity has projections $v_r \cos i'$ along α and $v_r \sin i'$ along δ. The relative velocity with respect to the observer is then $v_r \cos i' - (2\pi R_\mathrm{E}/T_\mathrm{E})\cos\varphi$ along α and $v_r \sin i'$ along δ. Then divide by h to find the respective angular velocities. The RA component turns out to be much larger, so it's this component that determines what time τ the satellite's image will get to spend on one pixel.

(6) **2019 T14B** Given that the Airy disk of a satellite isn't much larger than a pixel, the solution assumes that each pixel gets all the photons within the Airy disk for time τ. Of course, this is just a rough estimate.

(7) **2019 T14B** The final bit of the solution is overcomplicated. All you really care about is whether $\Phi_\mathrm{MASAT}\tau$ or $\Phi_{19.5}\tau_\mathrm{exp}$ is larger (because the latter indicates the visibility threshold of the CCD).

(8) **2020 T2** Assume that the Earth doesn't rotate around the Sun.

(9) **2020 T3B** There's no cosmological expansion within the Milky Way, so this part of the problem doesn't make any sense except as a maths exercise.

(10) **2020 T6B** Their geometry is incorrect. It's true that $\angle SAC = 90^\circ$, $\angle SBA = 90^\circ$, and $\angle ABC = 90^\circ$; however $\angle SBC \neq 90^\circ$. The correct answer to this part of the problem is

$$\Delta t = \left(\frac{P\Delta h}{2\pi r}\right)\left(\frac{\tan\theta_0}{\sqrt{\sin^2\theta_0 - \sin^2\beta}}\right).$$

(11) **2021 T2.3** This model borders on unphysical – if you assume that the Earth and its atmosphere are a single black body, the radiation exchanged internally (ground-atmosphere) mustn't enter into the radiation balance. For an actually rigorous treatment, see IZhO 2022.2 or IPhO 2024.1.

(12) **2021 T3.3** This solution to this part of the problem is missing. You should get a pericenter velocity of 4.1 km/s.

(13) **2021 T4.5** I have absolutely no idea what's going on here. If you do understand the solution, please email me so that I can write up a clarification. ?

(14) **2021 T7.2** When they say "the smaller star", they mean the one which is less massive.

(15) **2021 T8.3** Their value for the declination is inaccurate. I got $\delta = +0°50'$.

(16) **2021 T12.2** To clarify, in this problem θ is the true anomaly of the planet. Also, the deltas indicate infinitesimal changes, not any net changes over a large period of time.

(17) **2021 T15A.5** This is wrong! You should find that the potential energy is

$$U = 2Gm\mu \ln\left(\frac{r}{b}\right).$$

This error propagates in **A6**.

(18) **2021 T15C.1** Your answer ought to include T_{pl} as well.

(19) **2022 T3** The answer for the minimum velocity should be 700 km/s. Additionally, the time taken should be $t_0 = 5.3 \times 10^{17}$ s.

(20) **2022 T9** The angular velocity depends on the tangential velocity of Mercury rather than the full velocity. Using $e = 0.206$, we obtain 8.19 d. This is close to their numerical answer only because the eccentricity is small.

(21) **2023 T10** To avoid overdetermining the problem, assume that you don't know anything about the lunar orbit except that it's circular. You can find its radius while solving **A**, and then make use of this in **B**, **C**, and **D**.

(22) **2023 T10D** Here they want you to ignore the changes in the distance to the Moon – consider only the change in the relative velocity of the Moon with respect to the observer.

(23) **2024 T2** Because all wavelengths are spread out by a cosmological factor of $(1+z)$, you'll first need to divide the redshift dispersion σ_z by $(1+z)$ in order to obtain the real radial velocity dispersion. You should find

$$M_T = \frac{5c^2\sigma_z^2 D\Delta\theta}{2G(1+z)^2} = 1.4 \times 10^{44}\,\text{kg}.$$

(24) **2024 T6** The photon flux from the standard zero-magnitude source given in the data should be 10 000 photons/nm/cm^2/s (not counts).

(25) **2024 T11I** The original solution is exceedingly convoluted. You can simply read off the latitude where retrograde motion begins, and then find the true anomaly which corresponds to that latitude using spherical trigonometry. You should get the same answers that way.

USAAAO

I think that the problems up to 2017 are way too sloppy, and they're not challenging at all either. I recommend that you only pay attention to the papers from 2018 onwards.

(26) **2019 M4** The Friedmann equation you've been given is incorrect, use

$$H(a)^2 - \frac{8\pi G}{3}\rho - \frac{1}{3}\Lambda = -\frac{kc^2}{a^2}$$

and the fact that the universe is at critical density $\rho_{c_0} = \frac{3H_0^2}{8\pi G_0}$.

(27) 2019 L2E The indices in the given formula for r_{last} are wrong, change it to $r_{\text{last}} = \eta r_{\text{peak}}$.

(28) 2019 L2F The answer is missing from the original solution. I got $a_* = 0.61$.

(29) 2020 S1 December 29 is also a solution.

(30) 2020 S3B Special relativity does not apply at all when considering cosmological redshift, so this problem is wrong. One example where you would really have to use the relativistic Doppler effect formula is jets from a compact object.

(31) 2021 M3 There's a typesetting error in the problem statement. The station's mass is M, and the satellite's mass is m.

(32) 2021 M3 And a clarification: the relative velocity $\mathbf{w}$ of the satellite is with respect to the station's frame before the launch.

(33) 2023 S3 The problem statement needs a rewrite if the solution is to make any sense. Change "22 September" to the "September equinox", and note that equinoxes are defined with respect to the true Sun rather than the mean Sun. Only now will the equation of time come into play.

(34) 2024 M3B You need to assume that the planet is a black body.

(35) 2024 L1 You should assume everywhere that the camera captures both all the reflected radiation (mostly visible light) and the gray body emission (mostly infrared) with perfect efficiency. This is, of course, very unrealistic.

(36) 2024 L2A The original solution states the correct final result $l(L) = L + 2e\sin(L + \phi)$, but the rationale is wrong. The ϕ they use in the solution is the true anomaly for the March equinox rather than the mean anomaly, and it's not evident that their approximations hold after this correction. I suggest that you use this result as given and continue with parts B and C as usual – those are fine.

(37) 2025 6C Using their formula for τ, I get 48 Gyr. ?

(38) 2025 6D Molecular weight is a very obscure piece of astrophysical terminology, so I'll elaborate. We assume that all the atoms deep in the stellar interior are fully ionised. Hence each atom gives you Z electrons, for a total of $Z + 1$ particles. Their total mass is Am_{u} as the electrons are negligible. The mass per particle for a given species of atom is then $\frac{Am_{\text{u}}}{Z+1}$. The molecular weight μ of this species is defined as the ratio of the mass per particle and the mass unit m_{u}, i.e. $\mu = \frac{A}{Z+1}$.
Likewise, the mean molecular weight μ of a star is such that the total particle number in the star N_{tot} multiplies with μ to give the total mass of the star M:

$$M = \mu N_{\text{tot}} m_{\text{u}} = \sum_{i=1}^{n} \mu_i N_i m_{\text{u}}.$$

(39) 2025 6E The unit "dex" shouldn't scare you, it only indicates that the number has been obtained after applying a decimal logarithm.

(40) 2025 6E The original solution is wrong – you haven't got any information about the abundance of iron atoms in the Sun to begin with. Just use $(N_{\text{Fe}}/N_{\text{H}})_\odot = 4.7 \times 10^{-5}$, and this should give you $(N_{\text{Fe}}/N_{\text{H}})_{\text{cluster}} = 1.4 \times 10^{-7}$.

Contributing to the list

There are many errors missing from this file, and a single person can't hunt all of them down. This is where I ask for your help! If you have found an error, please email me so that I can add it to the list. Borrowing Donald Knuth's idea, I will award astrophysics money (i.e. ergs) for your troubles, as follows:

- **Clarifications.** Worth 5 erg. If you think that a problem statement is too ambiguous for someone to get the problem right the first time around, I can try to tidy it up here. Be explicit in what it was that had you confused.
- **Verifications.** Worth 10 erg. There are some errors here that I am not certain about. I've marked them with a **?**. I'd like someone else to double-check those. Message me with the number of the error (e.g. **(17)**) and attach some working which supports or disproves what's written down in the list. It doesn't have to be neat, just legible.
- **Wrong solutions.** Worth 10 erg. Some problems are correctly stated, but there are major issues with their solutions. What I count as an error is something which leads to a wrong final answer, either in the formula or in the numerical value. For example, a minus which disappears in one line of the solution but reappears in the next is fine with me – this sort of typo is quite common and not too harsh on the reader. Should you notice a significant error, please:
  1. Explain why the official solution is wrong.
  2. Show me what the correct answer is.
- **Wrong problems.** Worth 15 erg. Occasionally there are problems which are so wrong that one cannot patch up the solution and call it a day. One way this can happen is when a problem author forgets about a key physical effect, and the setup actually does things which are completely different from what the problem statement hints at (e.g. instability instead of oscillations). If you think a problem is wrong, please outline why. There should be enough detail so as to convince a fellow student.

The competitions that I'm tracking are IOAA, IAO, OWAO, USAAAO, and BAAO. I'm generally rather slow to reply, but still, you could send me a reminder if I haven't addressed your query within a month.

Energy balance

Additions to the list are tracked and credited. If you want to stay anonymous, that's alright too!

Teo Kai Wen .... 115 erg
▷ (2), (3), (5), (14), (15), (17), (20), (26), (29), (30), (31), (32), (36)