Physics Olympiad Errata

This file lists all the errors in Physics Olympiad solutions that I am aware of. Even at the international level, solutions files have more errors than one would think. People can spend a lot of time searching for a mistake in their work, when in fact it's the official solution that is wrong. My hope is that having all the errors in one place will make it easier for students to go through the problems by themselves.

All problems and solutions can be found in my archives.

IPhO

For reference, I still haven't checked the papers from 2019, 2008, 2005 and everything before that.

(1) **2011 1.3** This part of the problem is wrong because the equilibrium about the Lagrange point in question is unstable. You can see this by considering the force on a stationary object displaced radially from the Lagrange point by a little bit (in the reference frame of the rotating objects). You will find that this force points away from the Lagrange point. The additional assumption of constant angular momentum is both false and redundant. See this article by Jaan Kalda for a detailed analysis.

(2) **2014 2B.8** The value for the surface tension is $\sigma = 0.12\,\mathrm{N/m}$ (without the 10^{-2}).

(3) **2017 2B.1** Depending on how you measure the arrival time, your answers in the next two parts may diverge significantly from those in the original solutions. So, to be explicit – assume the arrival of the P-wave corresponds to the instant when the seismomeder reading becomes nonzero.

(4) **2017 2B.2** Another comment – do not take any additional measurements for this part. Use only your results from **B1**.

(5) **2017 2B.3** And yet another clarification – assume that the first signal to arrive at DNP is indeed due to the wave travelling through the mantle.

(6) **2017 2B.4** The original solution is incomplete. We need to take the upper limit of the integral for X, and only then do we find $X = \frac{2}{ap}\sqrt{1-(pv_0)^2}$.

(7) **2017 2B.6** The result of this calculation is very sensitive to the denominators, and the original solution hasn't been careful with this. I get $T = 184.1\,\mathrm{s}$.

(8) **2017 2C.1** To make the problem statement less vague, you are being asked to find the potential energy of the slab of height h with respect to the ocean level.

(9) **2017 3B.1/3B.2** These two parts of the problem are wrong, do not attempt them. They expect you to work with a nonzero k and make use of the scale factor's time dependence from **A4**. But that was obtained using $k = 0$!

(10) **2017 3B.3** The "condition for inflation" you are expected to use is $w = -1$, not anything that comes later in the text.

(11) **2017 3D.2** To be a bit more rigorous than the official solution, the observational constraints are $-5.19 > n > -6.69$ and $n > -1.81$, and these cannot be satisfied simultaneously.

(12) **2022 2C** The model used here isn't self-consistent (as discussed in the solutions), and I think it's impossible to figure out what you are supposed to do if you are attempting the problem on your own. The rest of the problem is really nice.

EuPhO

Nothing here yet!

APhO

(13) 2003 2A The solution is incorrect because it doesn't account for the relativistic correction on the speed of light in a moving medium, which is of order $\Omega R/c$ too. This is the same correction as the one in Fizeau's experiment (for that, see Wikipedia or IZhO 2018.3). The final result should be $\Delta t = \frac{4\pi R^2\Omega}{c^2}$ as per this paper – the refractive index doesn't matter.

(14) 2003 2B $\Delta L = c'\Delta t$ is not the correct expression for the optical path difference. The OPD is what you multiply by the wavevector in vacuum k to get the phase difference $\Delta\phi$, so

$$\Delta\phi = \omega\Delta t = k\Delta L \qquad \Rightarrow \qquad \Delta L = \frac{\omega}{k}\Delta t = c\Delta t.$$

Then in the next part we have $\Delta L = 3.0 \times 10^{-12}$ m. After that we obtain

$$\Delta\theta = N\omega\Delta t = \frac{8\pi^2 R^2 N\Omega}{c\lambda}.$$

?

(15) 2015 2C The ratio of the magnetic fields is 0.3, not 1.0.

(16) 2015 2D.ii The inequality should go the other way, $\theta_{\mathrm{cr}} \leq \arcsin\left(\sqrt{\frac{B_0}{B_m}}\right)$.

IZhO

I think I've caught everything from 2018 to 2024, but the earlier papers are there for the taking.

(17) 2018 3.2.4 The numerical answer in the marking scheme is wrong. The one in the solution is correct.

(18) 2018 3.3.2 Using the same approach (switching to the rest frame of the flow, using Snell's law there, and then switching back), I find

$$\sin\beta = \frac{\sin\alpha}{n} + \frac{v}{c}\left(\frac{n^2-1}{n}\right),$$

implying a constant offset $B_1 = \frac{n^2-1}{cn}$. I got the same result using the formulae on this site. Then **3.3.3** would be wrong as well. The final two tasks are fine.

?

(19) 2020 1.1 I don't think it's allowed to use noninertial frames the way they do. My answer is

$$\varepsilon = +\frac{\omega_1^2 r_2}{g_0}\left(\frac{r_1}{r_2}\right)^2 = 1.5 \times 10^{-7}.$$

I found this by comparing the tension forces on a pendulum in equilibrium at midday and at midnight. The tension, summed with the Earth's and the Sun's gravitational forces, should equal the centripetal force for the pendulum bob's trajectory around the Sun. I made use of $\frac{r_1}{r_2} \ll \frac{\omega_1 r_1}{\omega_2 r_2} \ll 1$. I'm not sure about my answer, but certainly one should get something that depends on ω_1.

?

(20) 2020 1.3.1 The thickness of the border of the triangle should be $\Delta r = 2r_1 = 2\,\mathrm{mm}$.

(21) 2020 1.3.2 The thickness of the border of the star should be $\Delta r = 3r_2 = 0.3\,\mathrm{mm}$.

(22) 2021 1.1 The formulae for the frequencies are correct, but the values should be $\omega_1 = 6.14\,\mathrm{rad/s}$ and $\omega_2 = 10.20\,\mathrm{rad/s}$.

(23) 2022 1.3 The final answer should be

$$Q = \frac{8\sqrt{2}\varepsilon_0 mg}{\sigma}.$$

In going from equation 5 to equation 6, they've missed an extra factor of $\cos\beta$. This means you will need to find $\int_{-\pi/2}^{\pi/2} \cos^2\beta \, \mathrm{d}\beta$ rather than $\int_{-\pi/2}^{\pi/2} \cos\beta \, \mathrm{d}\beta$.

(24) 2022 2.9 The answer for α in the marking scheme is wrong. The solution has the right one, $\alpha = 0.014\,\mathrm{K}^{-1}$.

(25) 2022 3.6 The calculation is off by a hundred; The time is $\tau = 1.27 \times 10^{10}\,\mathrm{s}$.

(26) 2023 3.9 There is a typo in the formula for T. We should have $T \ll \frac{eV_0}{k_B} = 8.70 \times 10^5\,\mathrm{K}$.

USAPhO

I'm only collecting errors from before 2007. The solutions of the papers from 2008 and onwards are still maintained, and their most recent versions can be found here. If you spot an error in those, email Kevin Zhou.

(27) 1997 B1 In part E, the assumption that there's no induced field on the axis of symmetry is unphysical. The electrons rotating at any given radius are like the current in a solenoid, meaning that a layer of plasma at r_0 produces a homogeneous field for $r < r_0$, whilst its contribution for $r > r_0$ is zero. To obtain $\mathbf{B}(r)$, you should use Ampère's law for a rectangular loop between r and R, and the answer is $\mathbf{B}(r) = -\mu_0 e n_0 \omega \frac{R^2 - r^2}{2}\hat{\mathbf{k}}$. For part F, it follows that $\frac{F_{\mathrm{mag}}}{F_{\mathrm{el}}} = \frac{v^2(R) - v^2(r)}{c^2}$.

(28) 1998 B2 In part A, the number of protons is $Z = 56$. In the original solution they plug in $r_1 = r_{\max}$, but in reality $r_1 = r_{\max}/\beta$. This error propagates to part B, where I get $\lambda = 5.8 \times 10^{-9}\,\mathrm{m}$.

(29) 2007 B2 To clarify, in part A(iii) you're being asked to find the time-averaged magnetic field. The instantaneous magnetic field has a different form, which can be obtained using the Biot-Savart law for a single charge $-e$ moving with speed $\omega_0 R$. This would correspond to a magnitude $B_e = \frac{\mu_0 e \omega_0 R}{4\pi(R^2 + z^2)}$, akin to a monopole rather than a dipole.

(30) 2007 B2 Parts B(iii) and B(iv) are wrong, because the EMF must depend on the time interval Δt when switching on the magnetic field. If this is done at a constant rate, we have $\mathcal{E} = -\frac{B_0}{\Delta t}\pi R^2$, but then the next part of the problem wouldn't make any sense. The original solution follows the unfounded assumption that Δt equals exactly one orbital period of the electron.

NBPhO

(31) 2024 6D In Solution 4, the radial component of the normal force is not $\frac{mv_\perp^2}{r}$. The normal force N balances the normal component of the centrifugal force, so $N = \frac{mv_\perp^2}{r}\cos\theta$. We plug this into $N\sin\theta = m\dot{v}_\parallel \cos\theta$ (from Solution 3) to find $\dot{v}_\parallel = \frac{v_\perp^2}{r}\sin\theta$. You can follow the official solution after that, but note that the final integral doesn't have anything to do with the area of a circle. That would be $\int_0^1 \sqrt{1 - u^2}\,\mathrm{d}u$, which evaluates to $\pi/4$, not $\pi/2$.

InPhO

(32) 2014 7E One of the terms in β has an extra factor of $5/3$:

$$\beta = \frac{1 + f^{1/3} + (5/3)f + f^2 + f^{5/3}}{(1+f)^{5/3}(1 + f^{1/3})}.$$

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 physics money (i.e. Joules) for your troubles, as follows:

- **Verifications.** Worth 5 J. There are some errors here that I am not certain about. I've marked them with a $\boxed{\textbf{?}}$. 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.

- **Clarifications.** Worth 5 J. 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.

- **Wrong solutions.** Worth 10 J. 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 J. 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 aiming for IPhO.

Keep in mind that I am only tracking the competitions listed above, that is, IPhO, EuPhO, APhO, IZhO, USAPhO, NBPhO, and InPhO. If maintaining the file proves easy enough, I might include a few more in the future.

Energy balance

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

Teo Kai Wen .... 30 J
▷ (27), (29), (30)

Eppu Leinonen .... 10 J
▷ (31)

Alex Prodanov .... 5 J
▷ (19)