

Norwegian Olympiad on Astronomy and Astrophysics – Round 2 Statistics

General Statistics

From R1, we invited 96 students to participate in R2, and got submissions from 85 of them. This is comparable to last year when we invited 111 students and got 99 submissions. The problems were sent out and done during Week 4, and we got all of the submissions during the week with no extensions necessary.

The total score distribution is shown in Figure 1, with mean score $\mu = 11.44$ and standard deviation $\sigma = 3.56$ for the $n = 84$ students, again comparable to last year.

R2 Score Distribution

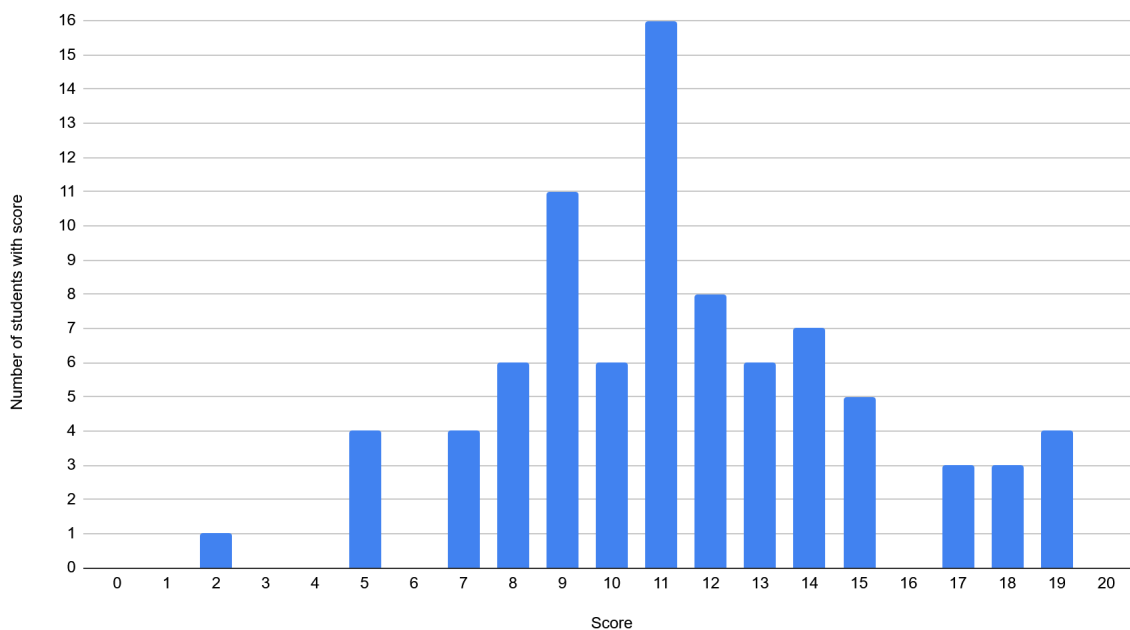


Figure 1: Total Score Distribution for Round 2

Last year, the cutoff was based on the combined scores for both rounds, so it is also interesting to look at the score distribution for the combined scores this year. The distribution has mean $\mu = 23.44$ and standard deviation $\sigma = 6.56$ for the $n = 84$ students.

Combined Score Distribution

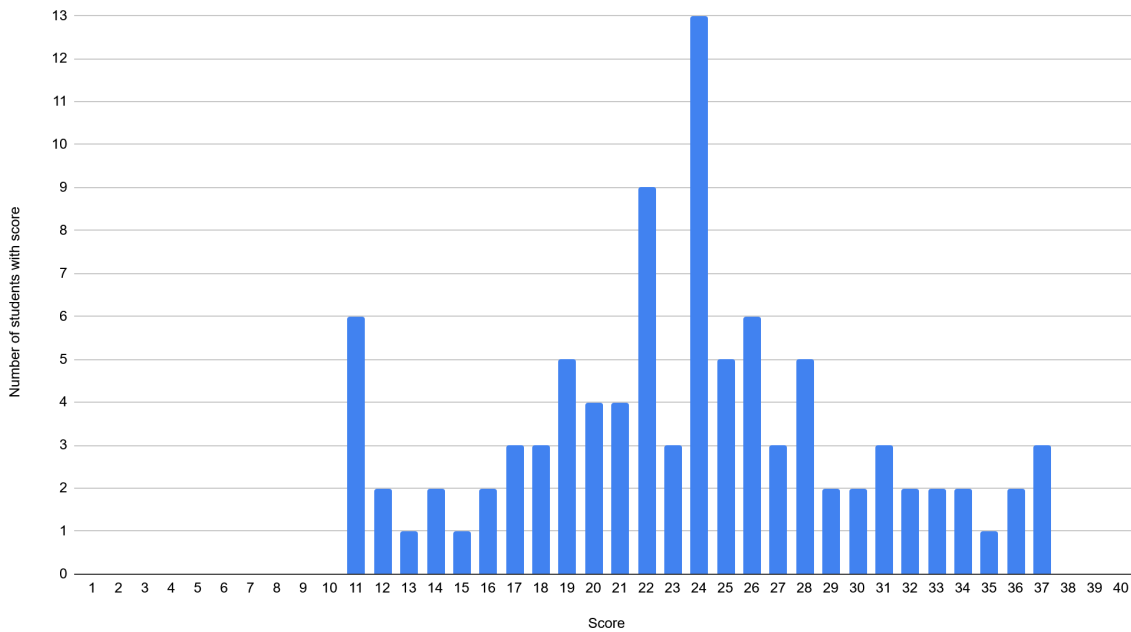
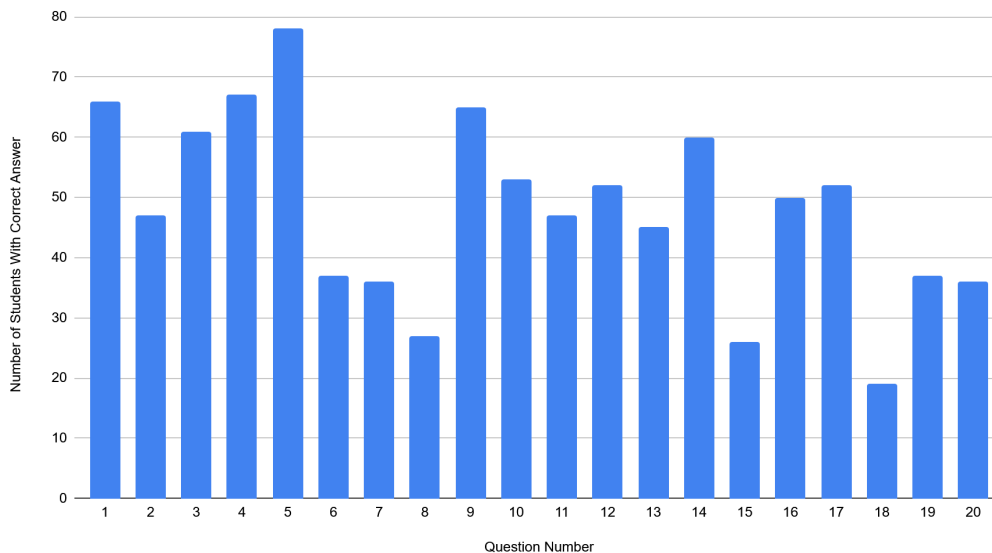


Figure 2: Total Score Distribution for both rounds

Finally, Figure 3 shows the per-question distribution, where we see that most questions were on a similar difficulty levels with a good mix of easier and tougher ones, although no single question was answered correctly by every student.

Number of Students With Correct Answers for Each Question



The general impression is that students struggle with more compound questions, as well as those requiring more general astronomy knowledge. We recommend learning the constellations in the Northern Hemisphere, looking at previous problem sets to use as practice, and looking at the handouts on the different topics in astronomy and astrophysics.

Per-Question Statistics

Surprisingly enough for R2, there were some students who chose not to put any of the four possible alternatives for every question, so not all the below numbers will add up to the total of 84 students.

Question 1

	Alternatives	Number of Students
Question 1	A	4
	B	6
	C	66
	D	8

This was a question on gravitational waves and what celestial bodies / system could produce detectable ones. The key here was the mass asymmetry; the initial draft of the question had little explanatory text and the thought was that the students would themselves be able to compute where mass asymmetry was present. This was deemed to be too difficult, but the explanatory text apparently made this question one of the easier ones from the round, with a vast majority getting it correctly.

Question 2

	Alternatives	Number of Students
Question 2	A	7
	B	16
	C	47
	D	14

This question was an extension of a R1 question on Doppler broadening, this time a bit more complicated because of the presence of a transiting exoplanet. Exactly half of the students got this question correctly - we didn't expect them to know of the phenomenon, rather to just reason themselves to an answer.

Question 3

	Alternatives	Number of Students
Question 3	A	17
	B	61
	C	6
	D	0

This question was on relativistic effects of rotation at the Equator. As a vast majority of students got the question correctly, it shows understanding of relativistic effects and an ability to eliminate wrong alternatives.

Question 4

	Alternatives	Number of Students
Question 4	A	7
	B	3
	C	7
	D	67

The first and probably simplest cosmology question of the round asked about which observation supports the fact that the universe is expanding. All the alternatives were true observations, so here we were looking for an understanding of the connections between astronomical observations and the conclusions they give us.

Question 5

	Alternatives	Number of Students
Question 5	A	0
	B	78
	C	3
	D	3

This question was on general relativity and the difference between it and Newton's theory. Only a couple of students didn't get this question, which shows a general solid understanding of the basics of relativity theory.

Question 6

	Alternatives	Number of Students
Question 6	A	17
	B	37
	C	23
	D	7

We now get into the territory of the more difficult questions, starting off with one combining Wien's Law and the Rayleigh criterion. The question in itself consisted of applying the two in addition to knowing the parallax method of measurement, as well as how to convert between parsecs and metres, which is a bit involved. Despite this, we expected more students to get the correct answer, as all of them were two orders of magnitude apart, allowing for significant calculating errors. This points to the fact that the students don't perform very well with compound problems requiring multiple steps.

Question 7

	Alternatives	Number of Students
Question 7	A	21
	B	36
	C	13
	D	14

This question was about the Summer Triangle and which constellations contained the stars making it up. We were looking for students who either knew what Andromeda looked like and saw that it wasn't in the figure, or those who knew the other constellations and could therefore eliminate Andromeda. Constellation questions are notorious at the Olympiad and usually the more difficult ones as it requires very specific astronomy knowledge that the students have to learn in their own time. So far, we have only asked about constellations in the Northern Hemisphere to limit the scope of what they need for the national rounds, but we still see there is a general lack of knowledge in this field.

Question 8

	Alternatives	Number of Students
Question 8	A	27
	B	17
	C	16
	D	24

This question was on coordinate systems in astronomy and which coordinate system altitude and azimuth belong to. It is quite surprising that this was such a polarising question, as we asked a very similar one last year, only asking about right ascension and declination. In addition, alternative "D" was Cartesian, and was considered a dummy alternative. We assume that the students went for it as it was the most familiar name, although the Cartesian coordinate system is simply the classic coordinate system with (x, y, z) coordinates, and not an astronomy-specific one like the others.

Question 9

	Alternatives	Number of Students
Question 9	A	3
	B	65
	C	14
	D	2

This question was on the time of rising of a star and was regarded as one of the more difficult ones when making the problem set, so it is a pleasant surprise that most students went for the correct alternative. This might be due to the big spread of the alternatives, but the fact that very few went for alternatives C and D that point to the star rising later is positive.

Question 10

	Alternatives	Number of Students
Question 10	A	53
	B	0
	C	11
	D	20

This question was on what took the longest time between a photon travelling from the Sun's core to the surface, a photon travelling between the Sun and the Earth, and the exam duration and ISS orbit. Most students went for the correct alternative, and it is very positive that no one went for alternative B, realising it must be shorter than at least C and D.

Question 11

	Alternatives	Number of Students
Question 11	A	4
	B	47
	C	22
	D	11

This was another question we deemed to be very difficult, but again exactly 50% of the students managed to get it correctly. It had to do with the train tracks along a parallel, and required knowledge/intuition on relative velocities, as well as knowing which way the Sun moves. Most of the students who got it wrong seem to have probably added hours, rather than subtract, pointing to a need for a little more intuition on movement. We also added in the 21st of March as a parameter to test whether they would realise that day and night last the same on that day due to equinox.

Question 12

	Alternatives	Number of Students
Question 12	A	4
	B	17
	C	52
	D	11

This question was on combining information inferred from Doppler broadening with an empirical relationship, which is very important for later rounds, where the students will have to do data analysis. It is positive that very few students answered that the galaxy in question has the same luminosity as the Sun, and that most of the students went for the correct alternative in the order of magnitude.

Question 13

	Alternatives	Number of Students
Question 13	A	7
	B	22
	C	9
	D	45

This question was on inclination and the implications of inclination on orbital velocity. It didn't require any calculations, only intuitions. Most students were split between B and D, and the fact that B was chosen by so many indicates that it might have been written in a more complex manner, since it should be an alternative that is immediately excluded because it doesn't make sense. It states that a vector component is longer than the vector itself.

Question 14

	Alternatives	Number of Students
Question 14	A	13
	B	7
	C	3
	D	60

This question was simply knowing Kepler's second law, which a vast majority of the students seem to have understood. The figure is common in textbooks and is expected knowledge for R2.

Question 15

	Alternatives	Number of Students
Question 15	A	26
	B	26
	C	21
	D	10

This was one of the top three difficult questions and it had to do with determining the age of a star cluster from its HR diagram. The process of doing so was described in enough detail in the problem text that the students should have been able to do it, but we see that a lot of them struggled, possibly because of not knowing what exactly was meant by "straying away from the main sequence". Combined with insight from some of the other questions in this round, it could point to a general struggle in reading long questions and understanding what the contents of a longer text tell you.

Question 16

	Alternatives	Number of Students
Question 16	A	50
	B	4
	C	14
	D	16

Back to some easier questions, this one had students apply conservation of energy for elliptical orbits, requiring them to either know or derive the expression for gravitational potential energy. Most of the students successfully did so, which was to be expected.

Question 17

	Alternatives	Number of Students
Question 17	A	52
	B	15
	C	12
	D	5

Back to a more general-knowledge based question, this one asked about the source of interstellar extinction, which most students recognised to be interstellar dust. A significant portion went for dark matter / black holes, pointing to a bit of a lack of understanding of dark matter or dark holes as concepts and how they interact with light.

Question 18

	Alternatives	Number of Students
Question 18	A	19
	B	33
	C	22
	D	9

Another difficult question, this one having to do with the relationship between apparent magnitudes and luminosity. The question was given to make students realise that the fact that something is very bright in our night sky doesn't mean it's more luminous than something else - it could just be due to distance. Pogson's formula was provided, but even with it, many students struggled finding the ratio, again pointing to general difficulty with more compound problems.

Question 19

	Alternatives	Number of Students
Question 19	A	9
	B	13
	C	24
	D	37

Another question on constellations, this time requiring the students to know two things: 1) the planets follow a line known as the Ecliptic as seen from Earth; 2) the Ecliptic runs through the constellations we know to be part of the Zodiac. We looked for those that either understood that Ursa Major is not part of the Zodiac, or those that knew that the other three were. We were also a little tough in adding Ophiuchus as an alternative, which is not generally known to be in the Zodiac.

Question 20

	Alternatives	Number of Students
Question 20	A	13
	B	36
	C	26
	D	8

In R1, we asked for the formula for escape velocity, while this question required applying said formula. It is surprising that there was a little bit of a split between the alternatives, but positive that the alternative chosen most was the correct one.