

Norwegian Olympiad on Astronomy and Astrophysics – Round 1 Statistics

General Statistics

The multiple-choice problem set for Round 1 was sent out to schools in week 42, and the schools had until the end of week 45 to send back their students' attempts. After these three weeks, we received 223 submissions from 28 different schools spread around 9 counties (fylker). The previous year, we had 153 submissions from 25 different schools. Out of the 204 submissions, 28.92% were girls, keeping the ratio from last year.

Figure 1 shows the total score distribution with mean $\mu = 9.95$ and standard deviation $\sigma = 3.87$ for the $n = 204$ students. The maximum possible score was 20, and was attained by only one student.

Total Score Distribution

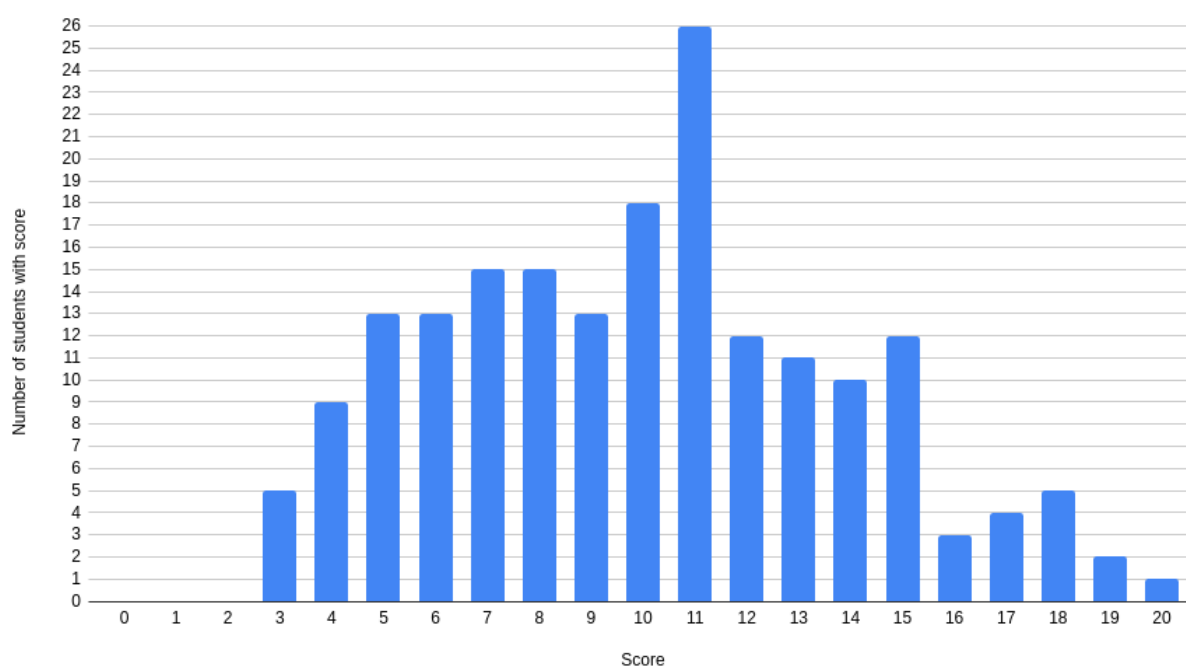


Figure 1: Total Score Distribution for Round 1

We have also looked at the distribution for correct answers to the questions, with its histogram shown in Figure 2. No single question was answered correctly by every student, and we can clearly see some questions that posed a big problem for the students, which we'll go through on a question-by-question basis.

Number of Students With Correct Answers for Each Question

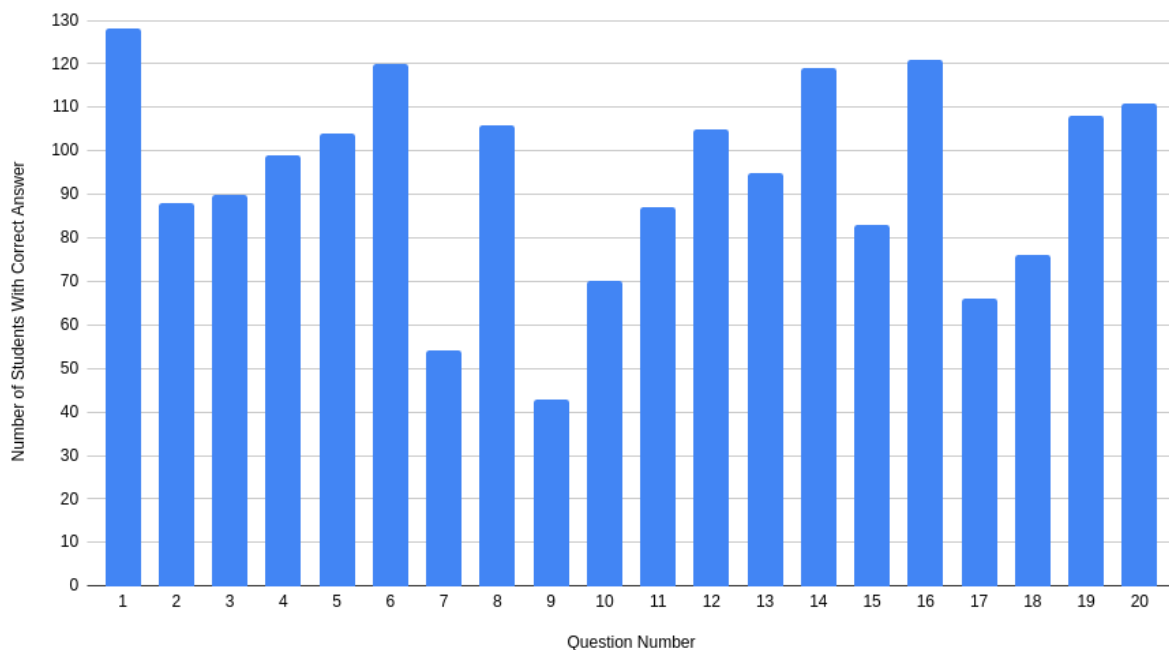


Figure 2: Number of students to correctly answer each question.

Per-Question Statistics

You will notice that quite a few of the questions below do not add up to a total of 204 students - some have actually chosen not to go for any of the alternatives, which is surprising, as the worst case scenario is a 25% chance to get a point, and there are no negative points involved, plus we don't ask to see their work.

Question 1

This question asked to reason why not every Full Moon is a lunar eclipse as was seen as the introductory question to the set which most, if not all students should have got right, at least by process of elimination.

	Alternatives	Number of Students
Question 1	A	141
	B	10
	C	36
	D	17

We see that a vast majority of the students managed to answer correctly, but that a substantial number of them went for alternative C, stating “Because lunar eclipses happen at New Moon, when the Moon is between the Sun and Earth.”, indicating that they might have mixed up lunar eclipses and solar eclipses, despite the provided figure.

Question 2

This question built on the previous and asked for another explanation for why the Moon could still be observed as having a red tinge even after the eclipse.

	Alternatives	Number of Students
Question 2	A	47
	B	95
	C	50
	D	12

Although many students answered this question correctly, the majority went for either alternative A, stating that the reddening was due to the tidal lock that prolongs an eclipse (which it does not), or alternative C, thinking it was due to the Doppler effect. Both point to a general lack of reasoning for why different astronomical phenomena happen, given that we considered all the other alternatives to be absurd in making the questions. This can probably be attributed to a bigger focus being put on calculations, which the students seem to perform well on, as we'll see in the statistics for algebraic and calculation problems.

Question 3

This was a question on calculating angular radii, where we provided an explanation for the small-angle approximation, as well as the conversion between degrees and arcminutes.

	Alternatives	Number of Students
Question 3	A	28
	B	34
	C	39
	D	100

Almost half of the students answered this question correctly, with the other half being evenly spread out between the other alternatives. The small-angle approximation might have been confusing, as it technically was not necessary to use it to solve the problem, since the students have calculators available and can simply just take the arctangent of the quotient, but it is an important tool that will be quite helpful in later rounds and important to understand.

Question 4

This question described different attributes of the transit photometry method for detecting planets and asked which one would be false.

	Alternatives	Number of Students
Question 4	A	29
	B	33
	C	109
	D	32

We see that more than half of the students managed to get the correct answer, pointing to both an understanding of the transit photometry method, but also reading comprehension, as alternative C specifically described a scenario where we get a lot of false positives and said that it would lead to a low rate of false positives.

Question 5

Another question on transit photometry, where we asked why the bottom of a brightness curve isn't completely flat.

	Alternatives	Number of Students
Question 5	A	21
	B	22
	C	113
	D	48

It is great to see that most students got this question right, even more than for the previous transit photometry question, which we thought to be more straightforward. Approximately half of those who got it wrong chose alternative D, which is essentially the opposite of alternative C, which, although wrong, points to an understanding that it has to do with different brightnesses in the different regions of a star. Additionally, the very next question essentially restates alternative C, which could have led to the students going back and choosing the correct alternative, which is great, since questions even at the international level hold valuable information for previous ones, and reading comprehension is quite essential.

Question 6

As mentioned above, this question restates alternative C from above and asks why exactly this darkening can be observed.

	Alternatives	Number of Students
Question 6	A	28
	B	131
	C	9
	D	35

A vast majority of students got this question correctly, assumedly applying the intuition that brighter=hotter.

Question 7

This question was on Doppler broadening, which has been asked previously in another round, only presenting the spectra and asking why they could get brighter, while we wanted the reasoning to go the other way around this time.

	Alternatives	Number of Students
Question 7	A	36
	B	41
	C	67
	D	59

It is surprising that this question posed so much difficulty for the students, especially given the fact that the phenomenon has been mentioned last year and the statistics on that one were

alright. This probably points to the question being a bit too difficult conceptually, as any talk about the Doppler effect in classes at school probably just boils down to redshift and blueshift, and line broadening is not a known phenomenon.

Question 8

This question was a simple application of the Doppler effect in conjunction with Hubble-Lemaitre's law, but with unit conversions.

	Alternatives	Number of Students
Question 8	A	38
	B	113
	C	18
	D	33

More than half of the students managed to solve this question correctly, which points to an understanding of the formulae as well as which units end up coming out as results.

Question 9

The Kuiper belt question was decidedly the one representing the biggest problem for the students.

	Alternatives	Number of Students
Question 9	A	47
	B	61
	C	57
	D	37

We are sure that the students have the mathematical background to calculate the difference in area between two triangles, so the difficulty must have come from not understanding what the question actually asks about. The fact that most went for alternative B suggest that most didn't take into account the fact that the distances given were from the Sun, and we were observing from Earth, despite the text in question being clearly underlined. This shows that the students need more conceptual understanding on what a more complexly formulated problem actually wants them to do.

Question 10

This question was on the application of Wien's Displacement Law on the CMB temperature. The alternative with most students was the correct one, but we do see a relatively even spread between the other alternatives. This question first required a conversion from degrees Celsius to Kelvin, then the application of the law that gives the wavelength in nanometers, and finally a conversion to see which of the alternatives actually corresponds to the obtained value, as all were of the same unit.

	Alternatives	Number of Students
Question 10	A	75
	B	31
	C	56
	D	40

It is surprising that quite many chose alternative D, since that is given in nanometres, which the law gives by default. The spread suggests that most students are not good at converting between units and understanding what units come out of which formulae.

Question 11

This question was on the formula for the escape velocity, where we in the text provided the way to derive the formula.

	Alternatives	Number of Students
Question 11	A	92
	B	73
	C	31
	D	6

It is great to see that a lot of students got the question right, but a little worrying that so many went for alternative B, meaning that they didn't plug the units into the formula and check that they end up with m/s, which is a valid way of both verifying the derivation and solving the question by checking the units of each alternative. In the future, we might make dimensionality analysis a bit more explicit and try to really strongly recommend the students always check their units when their result is a formula.

Question 12

This question was on the consequences of the Earth magnetic field reversal / fracture.

	Alternatives	Number of Students
Question 12	A	112
	B	12
	C	42
	D	35

Most students answered this question correctly, indicating an understanding of how the magnetic field affects both compasses and aurorae.

Question 13

This problem asked to compare the amount of light we get compared to Pluto.

	Alternatives	Number of Students
Question 13	A	9
	B	46
	C	43
	D	103

Just over half of the students got this question right, which could have been done either by calculating, or by just knowing that the amount of light follows an inverse square law with distance. In any case, one needed understanding of the concept flux as the amount of light from a star, which it seems most students have. Another thing is that the students either from just knowing, or from reading from the Kuiper belt problem, needed to know that the Earth is 1AU away from the Sun. It also seems that many used pure intuition when choosing their answer by choosing alternative C which is simply 10 times larger than the ratio between the distances.

Question 14

Another calculation question, this time on Kepler's Third Law, where the vast majority of students got the correct alternative, showing both intuition and understanding of the law and managing to plug in the values correctly.

	Alternatives	Number of Students
Question 14	A	11
	B	33
	C	128
	D	31

Question 15

Like we emphasise every year, observational astronomy is an incredibly important part of both our national olympiad and the international one. This time, we asked students to recognise Leo, one of the zodiacal constellations.

	Alternatives	Number of Students
Question 15	A	91
	B	32
	C	43
	D	37

Even though the alternative with most students is the correct one, the relatively even spread in the other alternatives suggests that the students are not at all familiar with the night sky, especially when going for alternative B, which is Ursa Major, i.e. probably the one constellation we expect every child to know. Constellations are a question every single round, every single year, and students should know at least the very basic ones for round 1, which does not seem to be the case for many.

Question 16

The mandatory HR diagram question, this time made substantially easier due to what we perceived to be a difficult rest of the problem set.

	Alternatives	Number of Students
Question 16	A	26
	B	31
	C	134
	D	12

The vast majority of students chose the correct alternative, which could have been done either by knowing that the Sun must be on the main series, or by simply looking at the luminosity axis which essentially shows exactly where the Sun lies.

Question 17

This question is almost an exact carbon copy of a question from last year's R1, which we did to essentially try and give the students a free point, as it is an expectation that one has at least looked through previous problem sets. A mistake was made in the Norwegian version, translating "aperture diameter" as "brennvidde", but no one noticed this even last year, so an assumption is made that the students could manage to just plug in the number where the diameter was supposed to be.

	Alternatives	Number of Students
Question 17	A	46
	B	53
	C	31
	D	70

Although a lot picked alternative D, it is disappointing that quite a few picked alternatives B and C, showing that they might just be blindly plugging in numbers without actually understanding what the Rayleigh criterion asks for, despite us having a question on it every single year.

Question 18

This was a question on how long it would take us to get a reply from a spacecraft a certain distance away. It required reading comprehension to understand that the reply involves us sending a signal, and getting one back, i.e. the light having to travel to and fro the spacecraft.

	Alternatives	Number of Students
Question 18	A	25
	B	67
	C	81
	D	27

It is therefore not surprising to see that many were split between alternatives B and C, where alternative B does not take the way back into account. It is interesting that a few went for alternative A, maybe simply because this question is one of the last ones in the set and they didn't have time to properly go through them.

Question 19

This question asks about the relationship between the escape velocity and possible atmospheric leakage.

	Alternatives	Number of Students
Question 19	A	117
	B	35
	C	42
	D	7

It is great to see that so many students chose the correct alternative, showing reading comprehension and basic intuition where these molecules cannot reach the 11km/s needed to escape Earth just from a couple of degrees of global warming.

Question 20

This question asked about the strength of the gravitational field on Mars. If done via calculation, it is probably the most involved problem in this whole set, but simple intuition should have led the students on a thought train along the lines of "Mars has a different g to Earth (alt. C eliminated), and it is surely lower (alt. D eliminated), but not close to 0 as we know it to have significant gravitation (alt. A eliminated)".

	Alternatives	Number of Students
Question 20	A	22
	B	120
	C	26
	D	33

The spread in the alternatives shows that this might have been the process they went through.