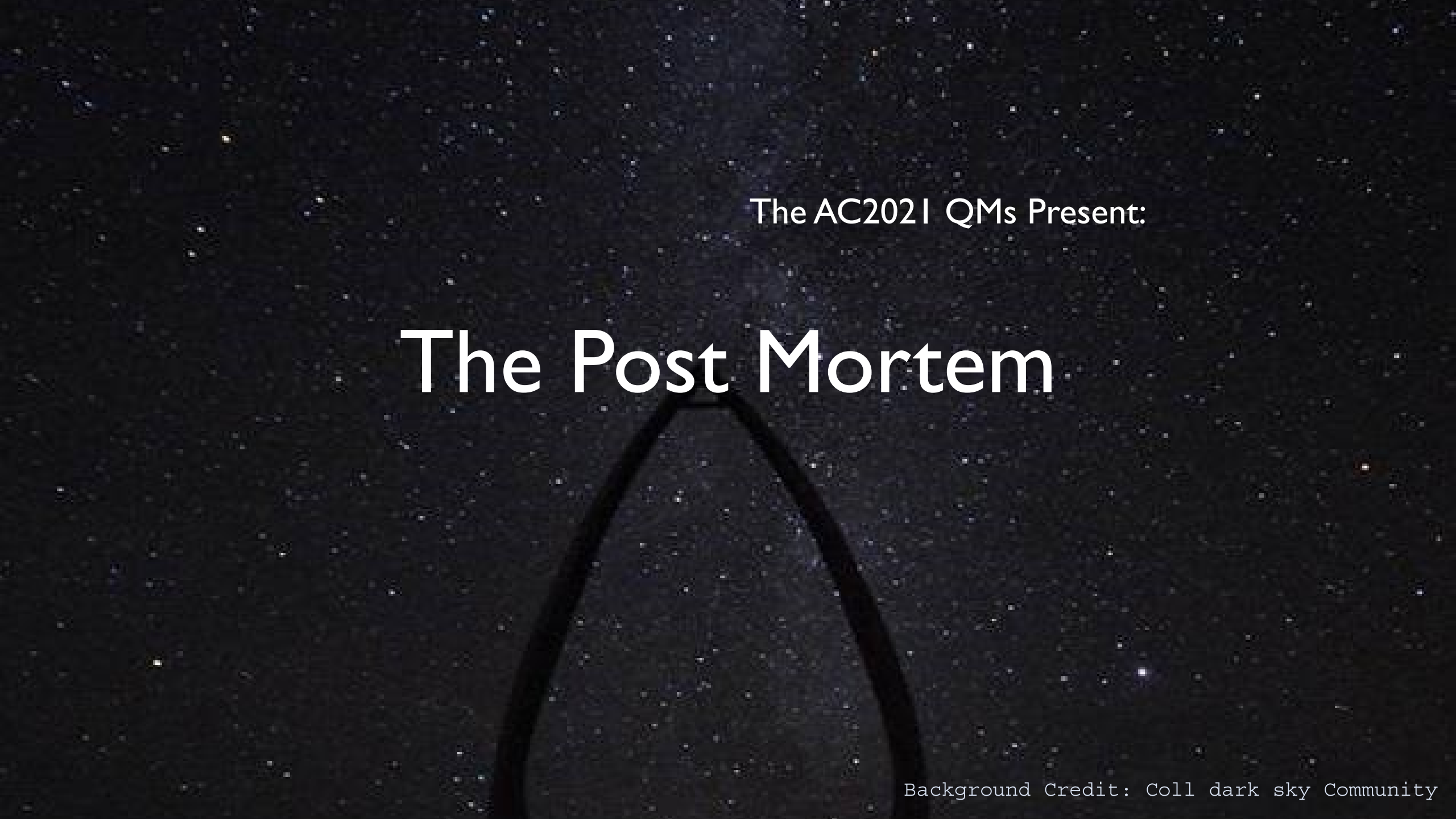


The AC2021 QMs Present:

The Post Mortem

Background Credit: Coll dark sky Community

AC2021

- One of the most confusing ACs in History.
- Initially planned for AC physically
- Switched to Online at the last possible minute
- Even so, I have had 22 Junior teams and 30 Senior teams this year. This is a record

Project Round

The Good

- Despite it being under heightened measures, some of the videos are still well done.
- There is evidence that effort was put in

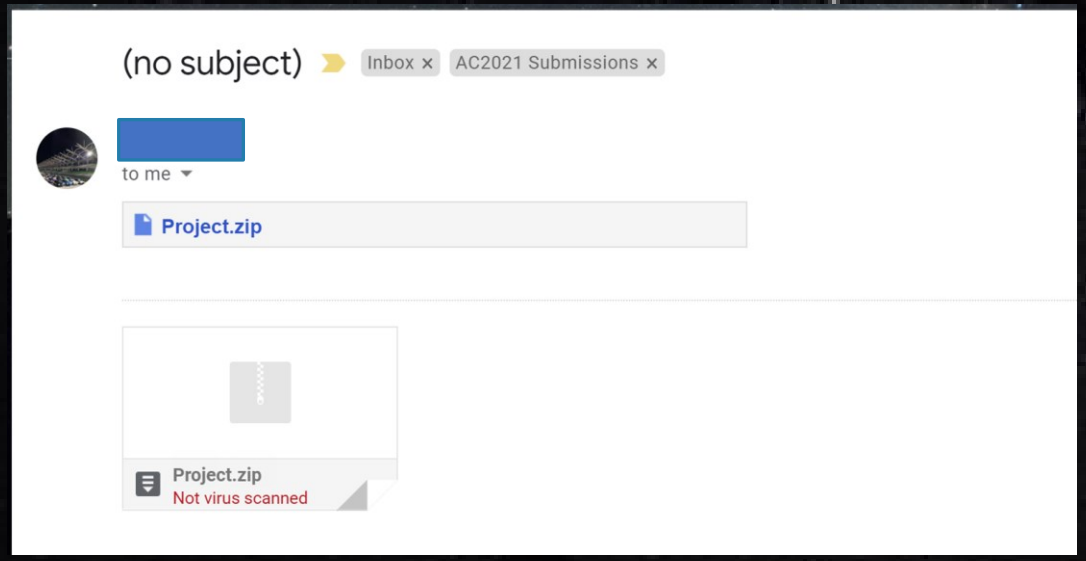
The Bad

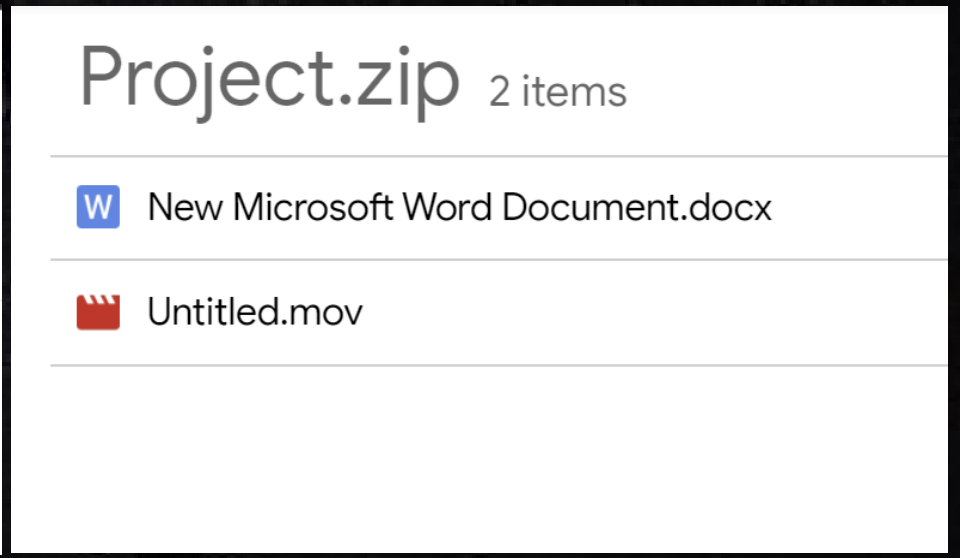
- Some people obviously did not read the information letter or project round infosheet.

12. It is **compulsory** for you to send in a transcript of your video if it is not subtitled. Failure to do so may incur a 30% penalty of your communication scores.

The Bad

- Some people liked to believe that we, the organizing team, know all of you.



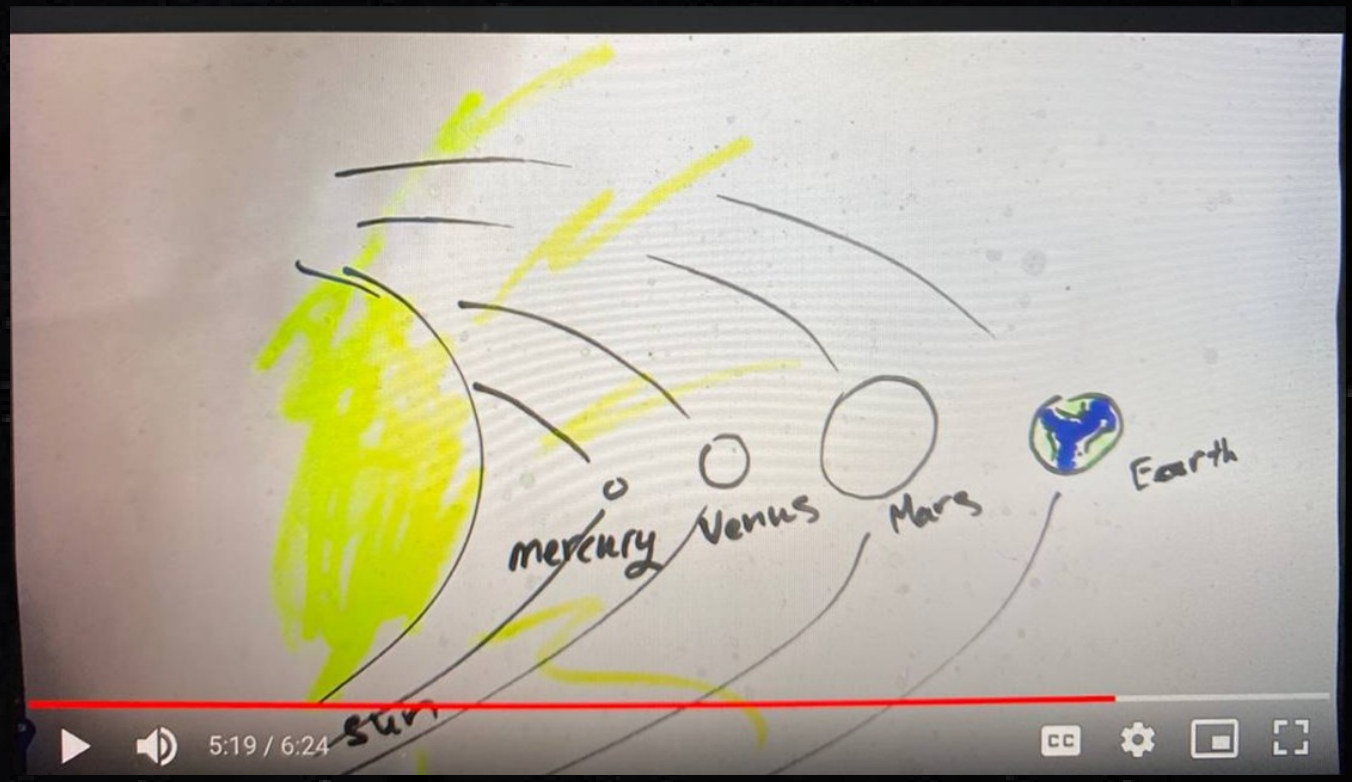


The Bad

- Memes which we did not understand
- Memes which promote wrong things

The Bad

- Obviously false information

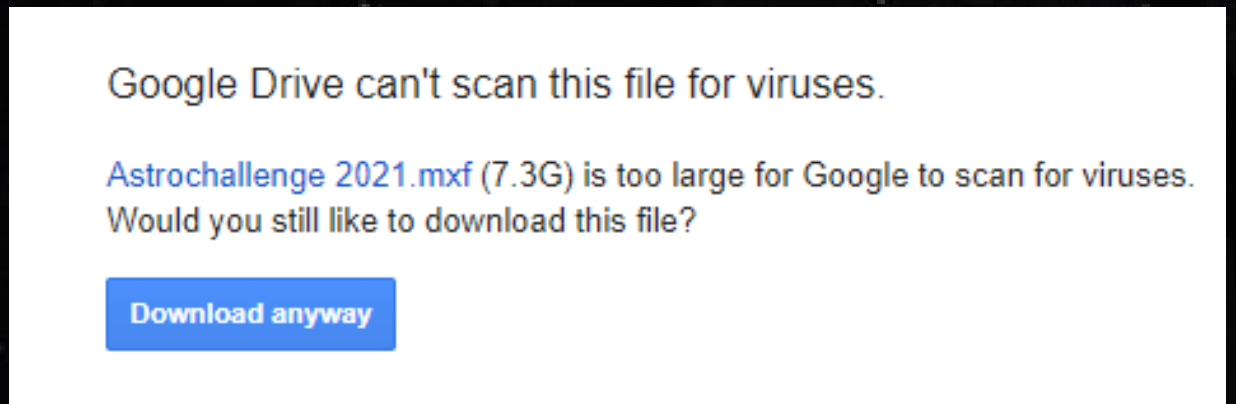


The Bad

- Some people believed in trying to hit the target at all costs.

10. Videos should not be excessively large – we recommend a 1 GB maximum. Videos larger than this limit often encounter playback issues. Then you will be at a disadvantage because we are unable to grade it as well.

For reference, the largest we received was 1018MB (6MB short of the target)… until we got a late submission



The Bad

- Some people deliberately slowed their video down so that they can exceed the time.

2. You will first choose **1 out of the 20** questions to **explain in a video** of **no more than 8 minutes in duration**. If your school is fielding multiple teams for the respective age category, you should not pick the same question as other teams from the same school. Exceeding the time limit will result in your video being penalized by the percentage exceeded. For example, if you submit a 10-minute video, your video will be penalized by **25%** (2/8).

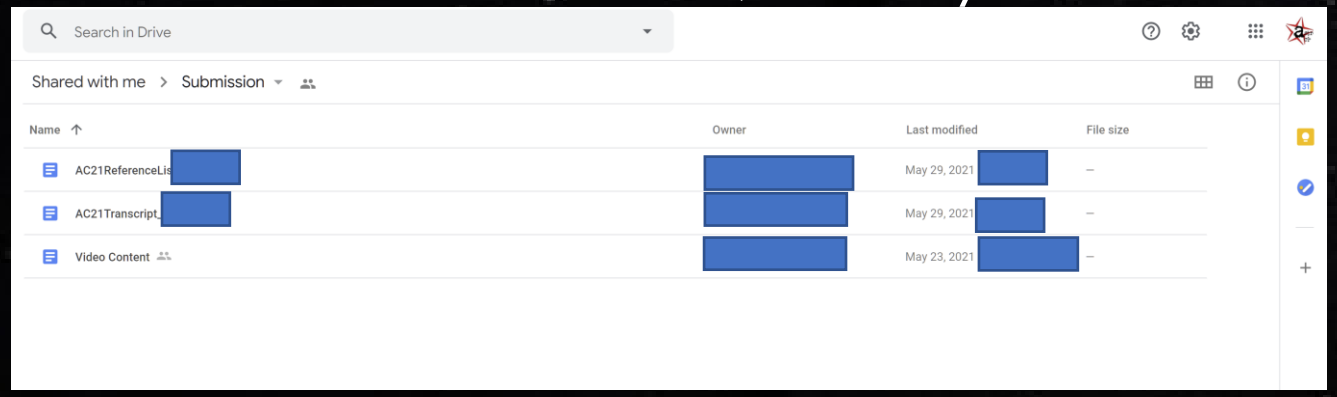
For reference, the longest video we received was 12m30s…

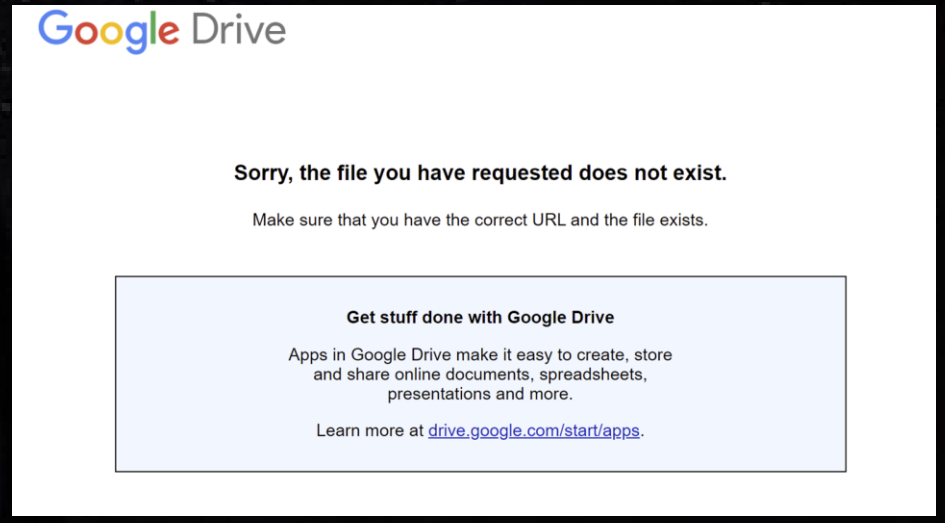
Score Weighting for Preliminary Rounds

Round Name	Junior	Senior
Individual	30%	20%
Team	30%	20%
Observation	N/A	30%
Project	40%	30%
Total	100%	100%

The Bad

- Quite some number of you failed to adhere to the deadline
- And Some did not even submit (or submitted links which did not work)
  - For reference, we did try to look for it

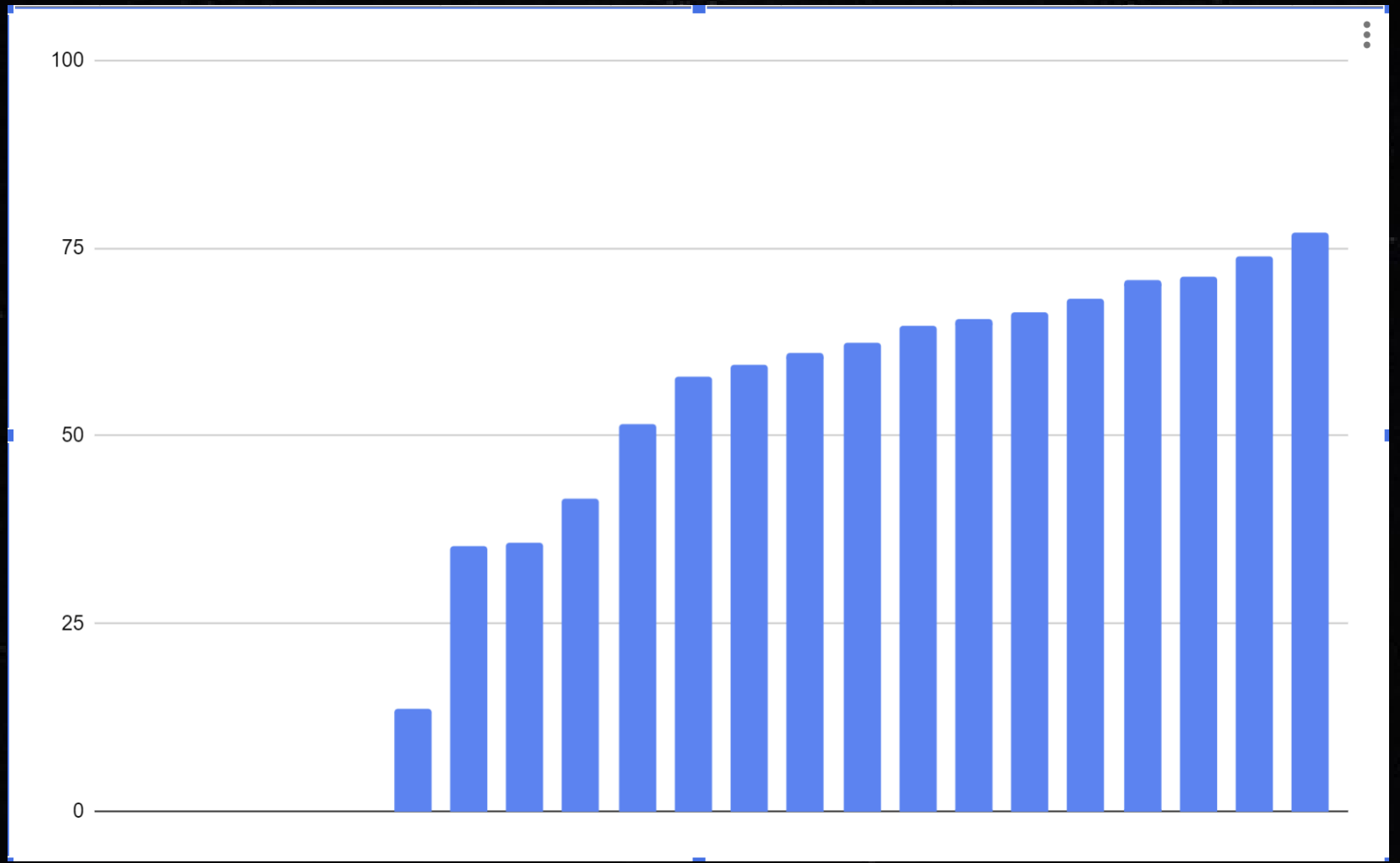




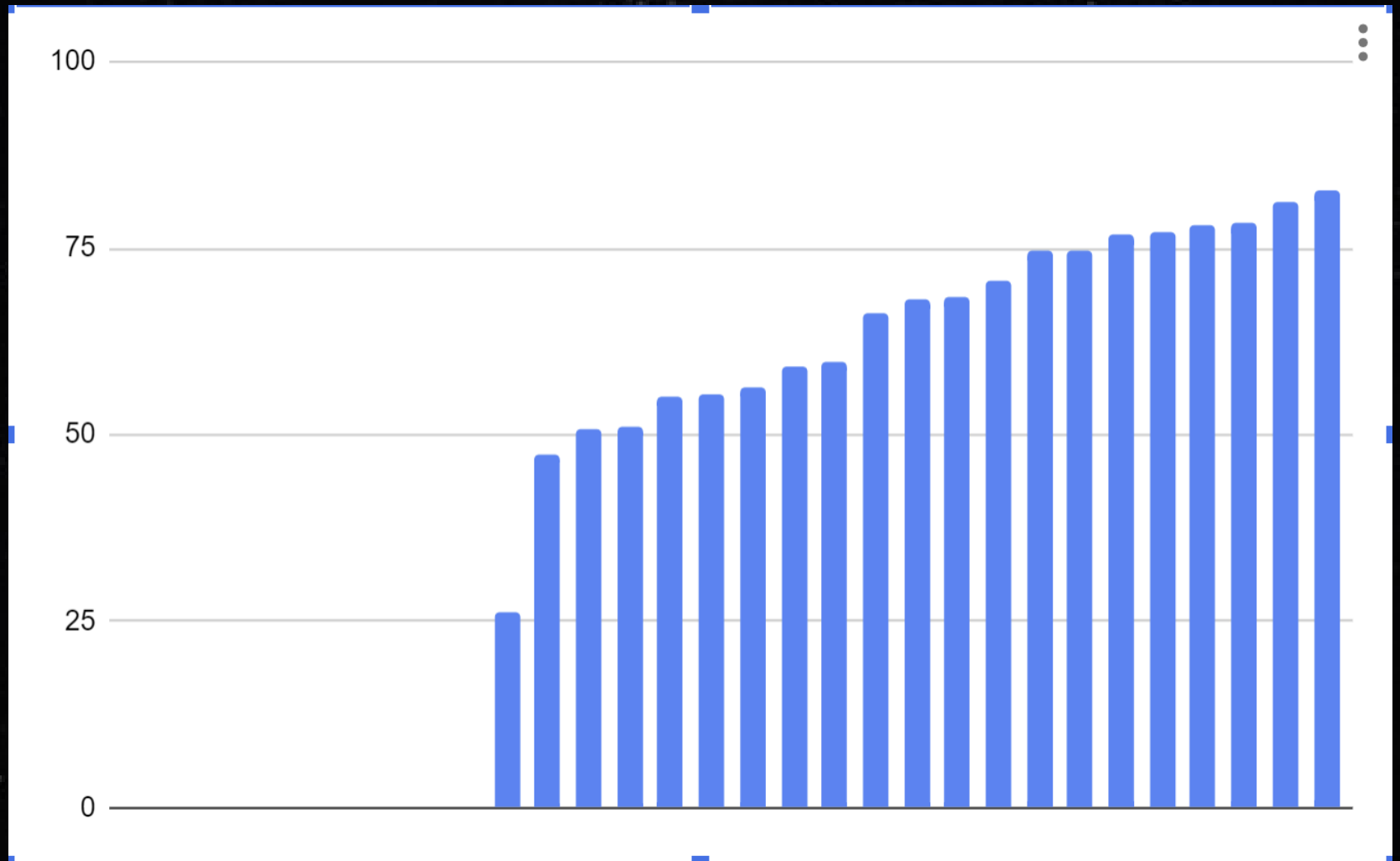
Summary of Questions

- Junior Most Popular: Q3 Black Holes
- Senior Most Popular: Q3 Black Holes and Q14 Fictional Spaceflight tied

Junior Score Distribution



Senior Score Distribution



DAQ Post Mortem

Q Setter Benjamin

Submissions

- Most of you adhered to the submission instructions
- Some of you submitted your DAQ in bits and pieces
- Some of you did not adhere to the deadline

The submission deadline for the DAQ round is on **Day 0 (29 May) by 1700**. The **deadline is strict**. Late submissions may not be entertained.

Each team is expected to work on this question **on their own** and you are reminded of the **need to credit all non-original sources**.

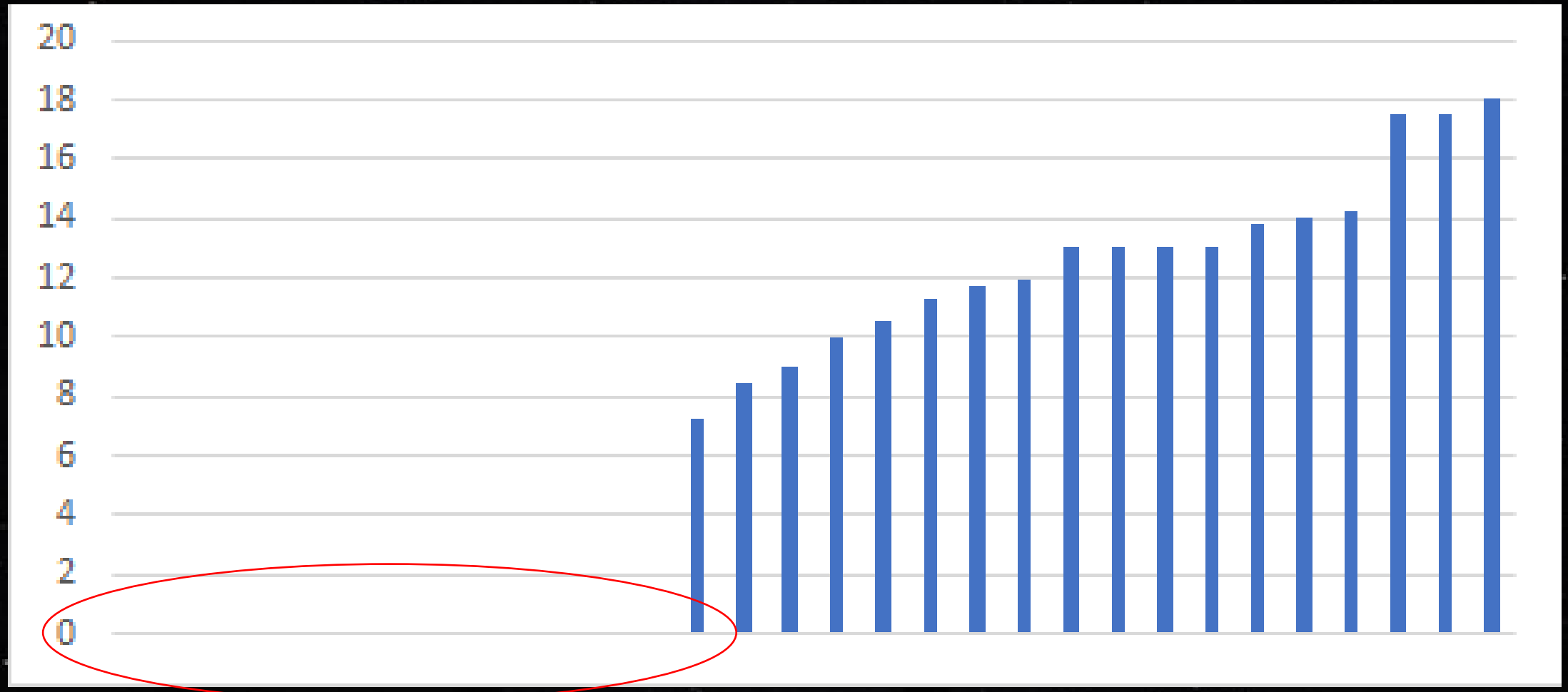
You are **required to zip all your deliverables into one zip folder for submission**.

You should **name your submission** in the following format:

[Full School Name]_[Team Number]_DAQ_Submission.zip.

For example: Lower Kent School_1_DAQ_Submission.zip

DAQ Score Distribution



The average relative flux per wavelength is higher for Galaxy A than Galaxy B (By calculation, estimated about 135 for Galaxy A and 249 for Galaxy B) indicates the presence

had a mean spectroFlux_r / spectroFlux_u of ~ 7.1531 and the second group of galaxies with zero velocity dispersion had a mean spectroFlux_r / spectroFlux_u of ~ 4.1482. This

visible light). Therefore, since the second group of galaxies had a larger ratio of spectroFlux_r to spectroFlux_u than the first group, the second group of galaxies is much

The group of galaxies with the velocity dispersion calculations are redder as there is much more red light than blue light as seen from the lower spectroFlux_u to spectroFlux_r ratio as compared to the galaxies with velocity dispersion calculations.

1c) The group of galaxies without velocity dispersion is redder, because the mean values for the group of galaxies without velocity dispersion are

?

2.2 Colours

Dubious Terms

apparent luminosity of galaxy 1

the speed at which light approaches earth

The strong emission line of H alpha suggests that there are high volumes of H alpha present.

H+

H+

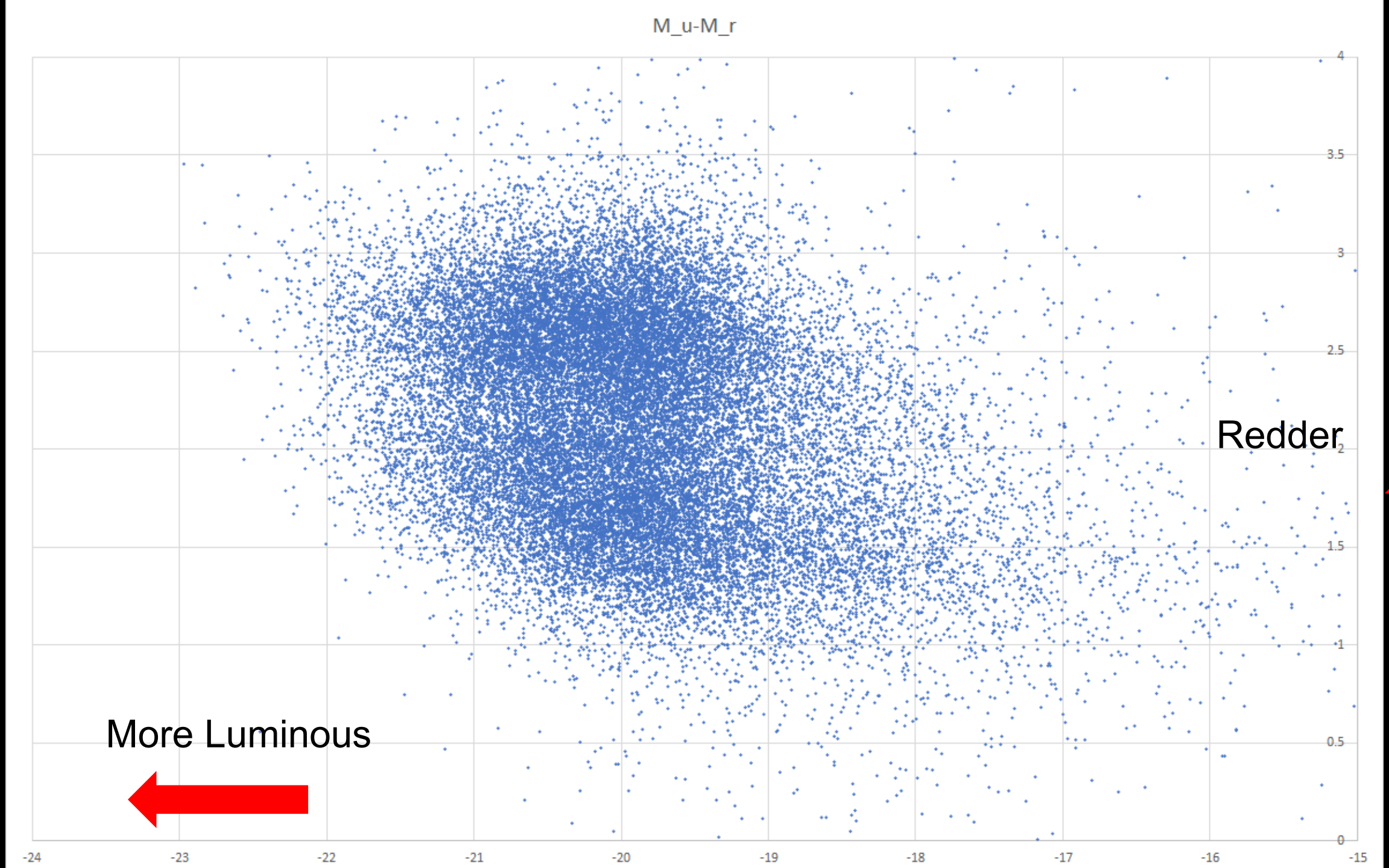
H+

Interesting units

proper distance = (4116km/s)÷(70km/s/Mpc)×(3.086×10^{24}cm/Mpc) = 181.5×10^{24}cm

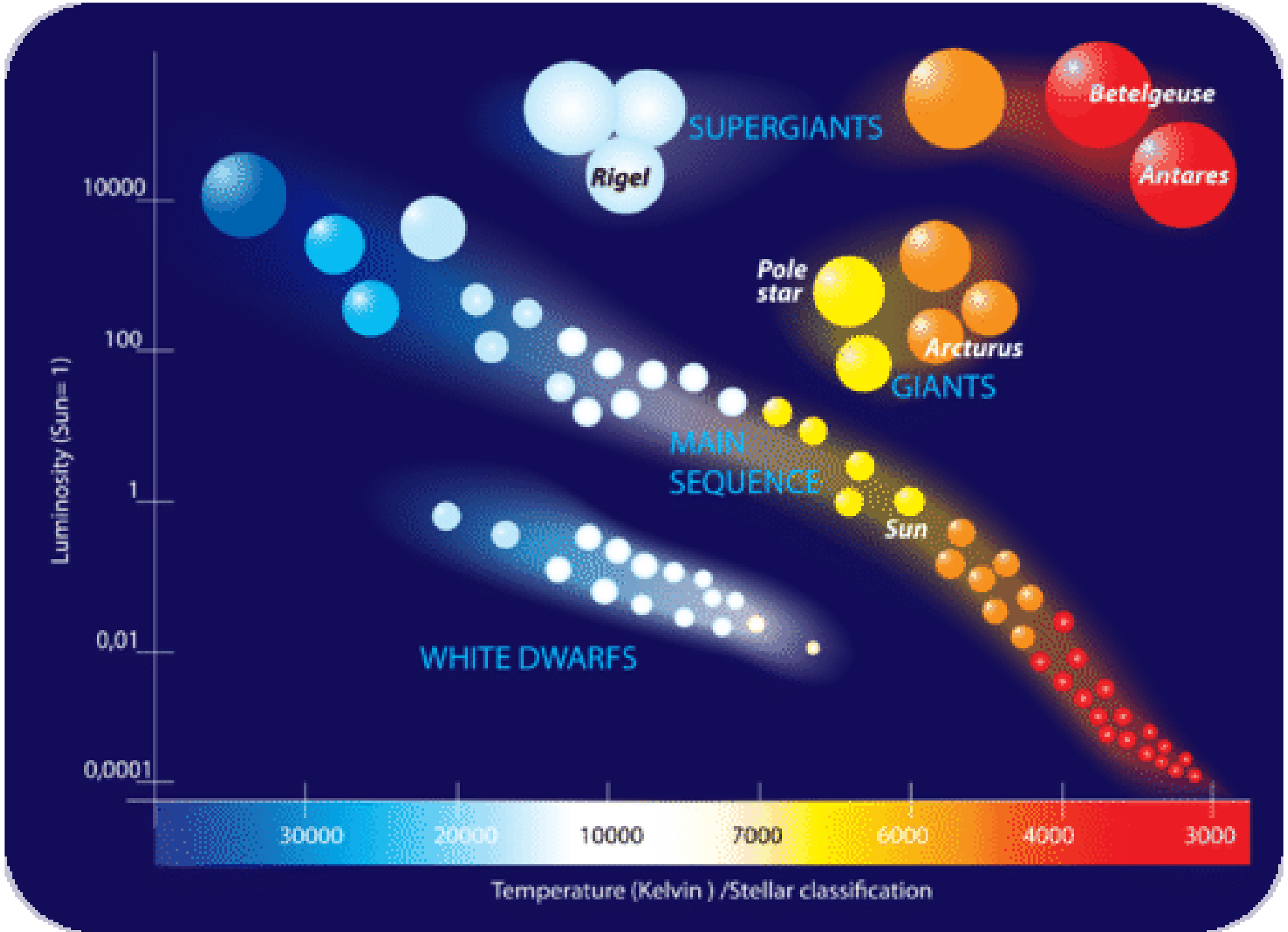
Approximate distance from earth:

- Galaxy A: 3.38×10^{26}cm
- Galaxy B: 9.33×10^{25}cm


M_u-M_r
4
3.5
3
2.5
2
1.5
1
0.5
0
-24
-23
-22
-21
-20
-19
-18
-17
-16
-15
Redder
More Luminous

Conclusion

- A galaxy with more active star formation does not imply one which is more luminous.
- Luminosity of a galaxy depends both on the luminosity of its constituent stars and the number of stars it contains.
- The luminosity of a star does not only depend on its colour/spectral class/surface temperature.


SUPERGIANTS
Rigel
Betelgeuse
Antares
Pole star
Arcturus
GIANTS
MAIN SEQUENCE
Sun
WHITE DWARFS
10000
100
1
0,01
0,0001
Luminosity (Sun= 1)
30000
20000
10000
7000
6000
4000
3000
Temperature (Kelvin) /Stellar classification

Night sky tour

Q Setter Grace

General Comments

- It was quite well done on a whole, the observation committee expressed that it was much more enjoyable to watch than the project round videos
- Quite some effort was placed in the videos.

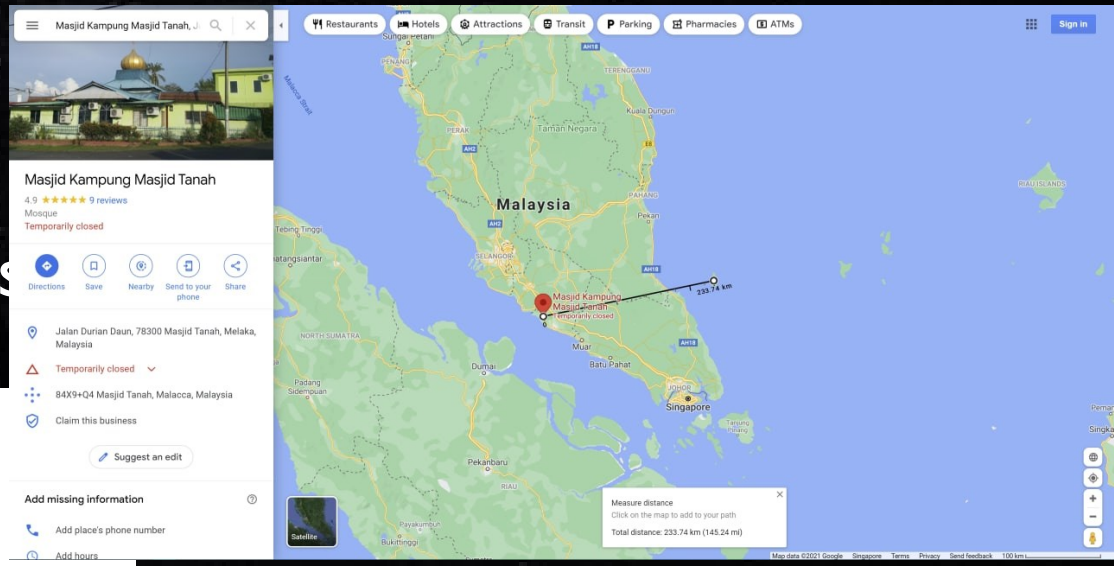
However

- Common Issues:
  - People failed to adhere to instructions
  - People went to pause the time...

However

Earth, Kampong Masjid Tanah, 17 m

- People failed to adhere to instructions



Date: Tuesday, 7th September 2021

Time: 9.00pm - 9.30pm

Venue: Tioman, Pahang (2,47°N, 104,10°E) 100m ASL

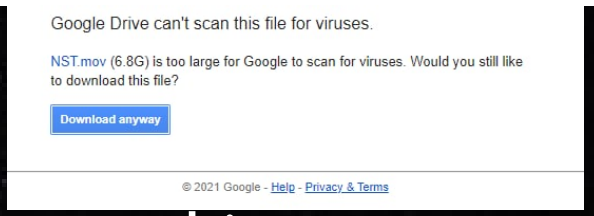
Target Audience: High school students of various backgrounds

Your Task:

However

You are required to submit three deliverables by **Sunday the 6th** of June 2021 at 1959hrs.

1. A 10 Minute MP4 Video of your Night Sky Tour
2. A Transcript of your video



- Transcript? Missing
- Video? Sent me .mov instead, and also this one:
- I did not ask for a zip. Some of you went to zip everything...

However

```
- Deep Sky Objects Background Images: OFF
- Ground (zero horizon landscape) and atmosphere: ON
- Projection: Stereographic
- Light pollution: 3
```

- People failed to adhere to instructions
  - People did not turn off DSO background images...
  - People did not change the ground

However

For the avoidance of doubt, while you are **not** encouraged to refer to other sources other than Stellarium, if you do so, you are required to submit **a list of references** in a word document or pdf file. You are required to submit **a transcript** in a similar format as well.

- What I meant by this:
  - please do not use any other sources or slides. In a real NST you do not have access to all these fancy images.
  - And you forgot to credit these images...

Last Words

```
Target Audience: High school students of various backgrounds

Your Task:
```

- Some of you produced videos which included inappropriate jokes, references and/or memes.
- Some of you produced videos which were obviously made by 1 person. By this logic, I should only expect 1 of you in the obs round... (BTW: they appeared full strength)

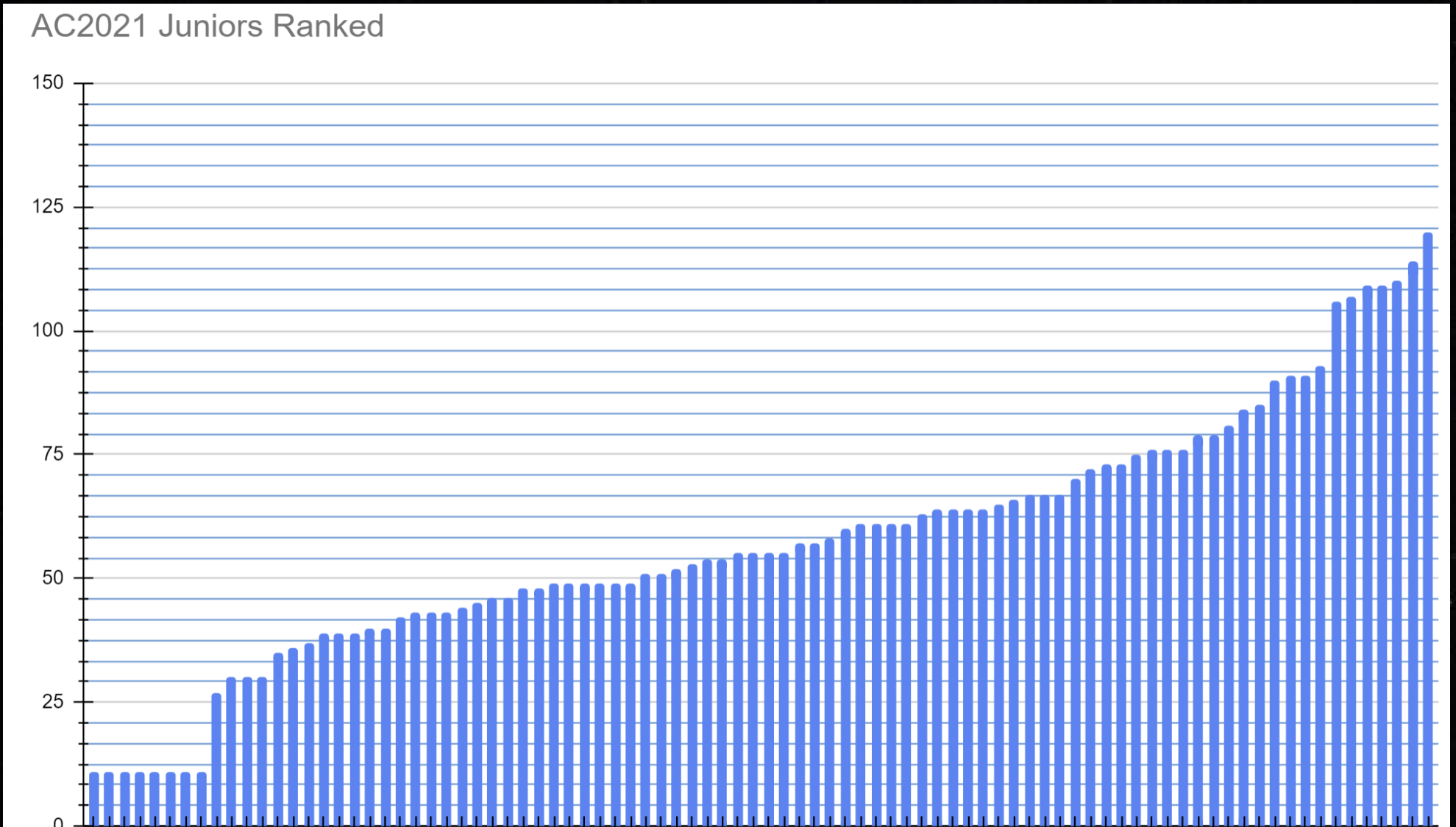
Please follow the link for further instructions: https://www.astrochallenge.org/2021/Documents/AC2021_NST.pdf

For the avoidance of doubt, **only the Observation Team from each school is required to make this video**. Scores for this video will be awarded to all teams from that school. The **same 4 persons** making this video should appear for other sections of the Observation Round as well.

If at any time you should have any questions or concerns, please do not hesitate to contact us.

Individual Round

Junior Scores



Total sample: 89
Hi: 120
75pc: 72
Median: 55
Mean: 56,9
25pc: 42,5

(Note this is after a 50 point moderation)

Junior MCQ

- Killer Question: Q38 (Practical Observation) only 5 correct

38. You are lost in a tropical forest at night. The crescent moon forms a sad face at you low in the sky because you have forgotten to bring a compass. Which of the following options correctly matches the moon phase and the part of the sky it is in?

(A) Waxing, east

(B) Waxing, west

(C) Waning, east

(D) Waning, west

(E) None of the above

Sad face is like this:

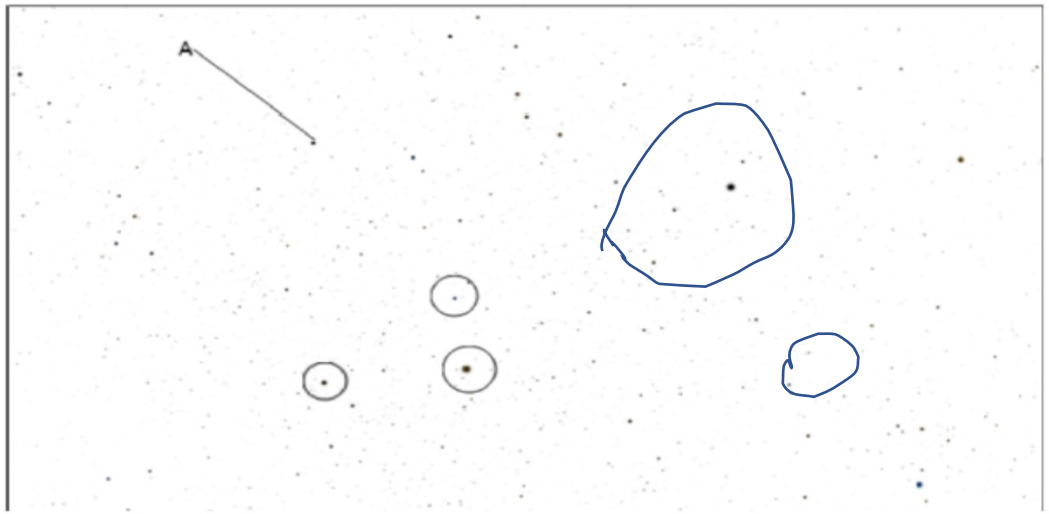
This means that the Moon the sun is above the horizon. As such, it cannot be night.

Hence: The answer is that this is simply impossible...

Junior MCQ

- Most Wrongs: Q27 (Observation) 64 wrongs

For Questions 29 and 30, please refer to the following image.



29. The three circled stars form a famous asterism in the night sky. What is this asterism?

(A) The tail of Leo

(B) Summer Triangle

(C) Winter Triangle

(D) Arrowhead of Orion

(E) Trick question. There is no asterism located there.

How to do this? Eliminate the options.

Option D is clearly a troll option.

If it is the winter triangle, you should be able to see Orion. You do not, so C is wrong.

Option A does look like the answer and shape. However, if it is correct, you should be able to see the sickle and regulus where circled. It is not there, hence A is wrong.

That leaves option B and E. Option B requires Altair (see Q 4). You do not see Altair circled. Hence B is wrong

Junior MCQ

- Most Blanks: Q17 (Calculation) 35 Blanks (Q16 the question which this is combined with has 34 Blanks

17. The moon has a mass of 6×10^{12}kg. What is the gravitational force acting on the moon?

(A) 1.05×10^{13}N

(B) 2.03×10^{13}N

(C) 3.04×10^{14}N

(D) 3.14×10^{14}N

(E) 2.30×10^{15}N

This is actually just F=ma

Junior MCQ

- Most Correct: Q26 (General) 63 Correct

26. Which statement correctly explains why Pluto is not classified as a planet?

(A) It is too far away from the Sun.

(B) It is not in orbit around the Sun.

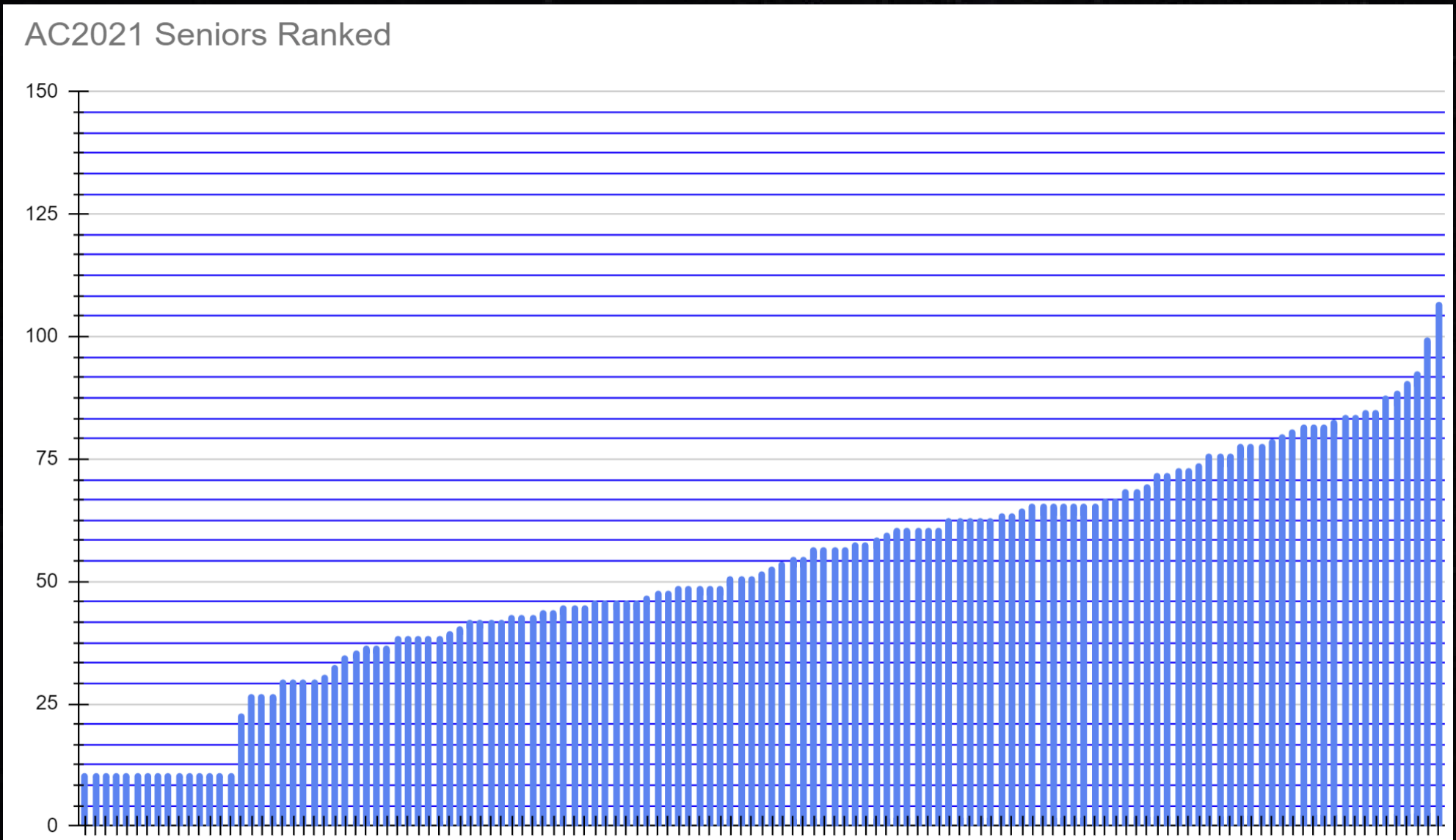
(C) It does not have sufficient mass to assume hydrostatic equilibrium.

(D) It has not cleared the neighbourhood around its orbit.

(E) It has no life on it.

Seems fine

Senior Scores



Total sample: 131
Hi: 107
75pc: 66,5
Median: 52
25pc: 39

Mean: 52,3

(Note this is after a 50 point moderation)

Senior MCQ

- Killer Question: Q38 (Practical Observation) only 4 correct

38. Your classmate Donovan has been an avid amateur astronomer for three years and owns a 6″ Newtonian reflector ($f/5$) with a manual equatorial mount. He wishes to do astrophotography and has sought your advice on what equipment to buy. Based on his current equipment, which of the following statements can you offer him as advice?

I He should get a light pollution filter to sieve out unwanted stray light entering his telescope.

II He should purchase an auto-guider to help him automatically track objects that his telescope is pointed at.

III A high-speed video camera and Barlow lens can be purchased for capturing detailed images of planets by utilising the large aperture of his telescope.

IV Since he possesses an equatorial mount and a fast Newtonian reflector, he can use a DSLR or purchase a dedicated astronomy imaging camera to take pictures of deep-sky objects like the Orion Nebula and the Andromeda Galaxy.

(A) I only

(B) III only

(C) II and III only

(D) I, II, and III only

(E) II, III, and IV only

Do it by elimination: Manual mount so II is useless

Then you are left with A and B only.

Then consider what a LP filter does...

Senior MCQ

- Most Blanks: Q11 (Theoretical Observation) 75 Blanks

11. Tom has bought a new Dobsonian Telescope with the specifications below. He is using a 1.25-inch 25mm Plössl eyepiece with an apparent field of view of 52 degrees. What is his true field of view?

Aperture	305 mm
Focal Length	1500 mm
Focal Ratio	$f/4.9$

(A) 0.41°

(B) 1.08°

(C) 0.87°

(D) 250°

(E) 2.08°

This question actually isnt particularly hard

Senior MCQ

- Most Wrongs: Q5 (Celestial Mechanics) 91 Wrongs

5. Billy was visiting his alien friend Timmy who had set up base at Mercury to observe our Sun. While there, Billy saw the Sun rising from the east, only to backtrack in the opposite direction and then set below the horizon again two Earth days later! Billy was bewildered. How can Timmy best explain what was observed?

   (A) Mercury is at perihelion and its angular rotational velocity has exceeded its angular orbital speed.

   (B) Mercury is at aphelion and its angular orbital speed has exceeded its angular rotational velocity.

   (C) Mercury is tidally locked to the Sun but wobbles just enough for the solar terminator to shift.

   (D) Atmospheric distortion creates this optical illusion.

   (E) None of the above explains the phenomenon.

Read the options clearly.

Senior MCQ

- Most Corrects: Q14 (Cosmology) 100 correct

14. Which of the following statements regarding Hubble's law is correct?

(A) It is a set of laws to regulate the operation and use of the Hubble Space Telescope.

(B) It is a set of laws to regulate the Hubble tuning fork.

(C) It is used to show that galaxies move away from us at a rate proportional to their distance from us.

(D) It is used to show that the Universe is flat.

(E) None of the above statements are correct.

Junior Team Round

Junior SAQ (Q1)

Setter: Nicholas P

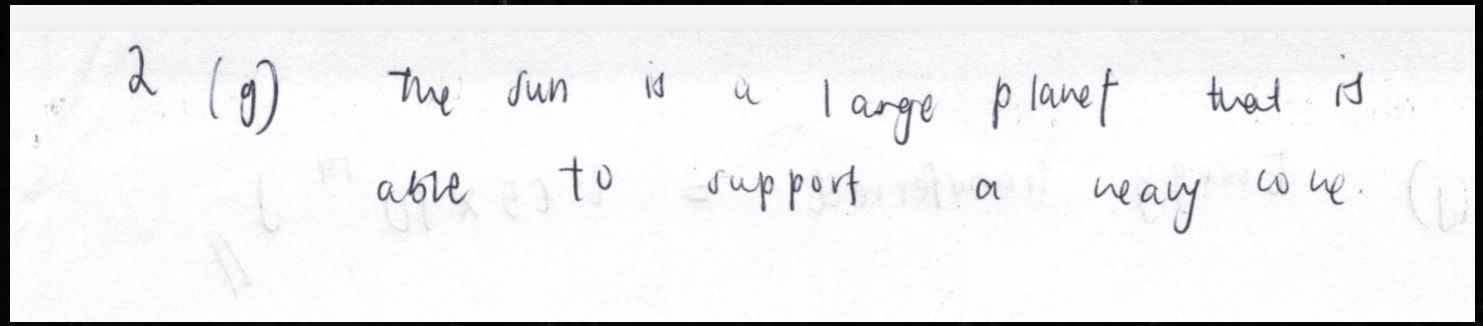
General Comments

- A lot of you fell for the trap
  - More to come later

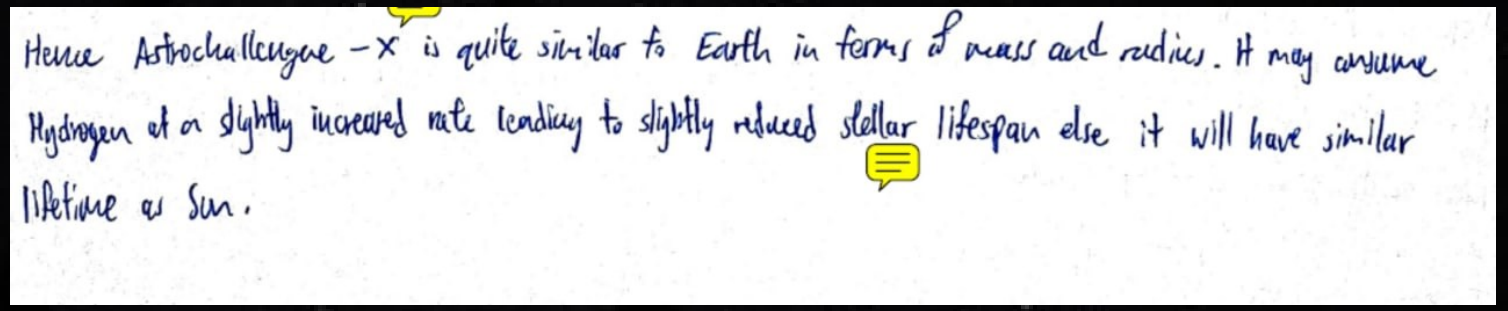
(f) The most important factor to determine the visibility of an object is its absolute magnitude. [2]

Short Answer Questions

- Remember me from 2019?



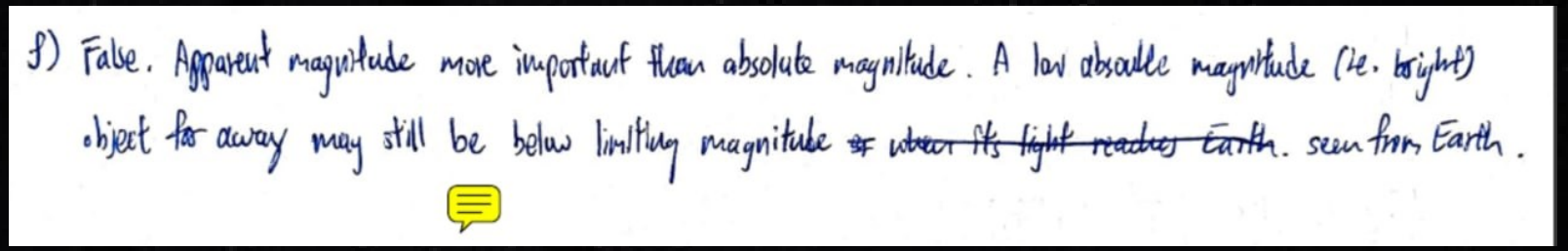
- This is what I got this year:
  - A star the radius and mass of the Earth...



Short Answer Questions

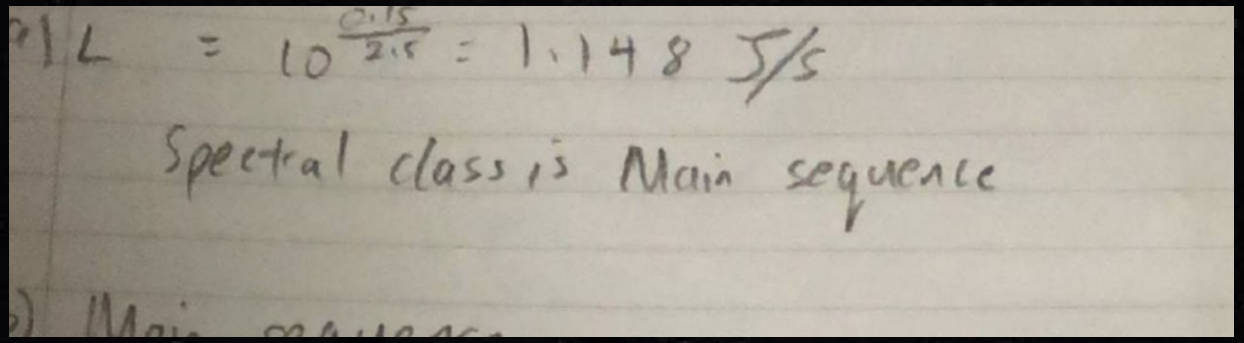
- Common Mistakes:

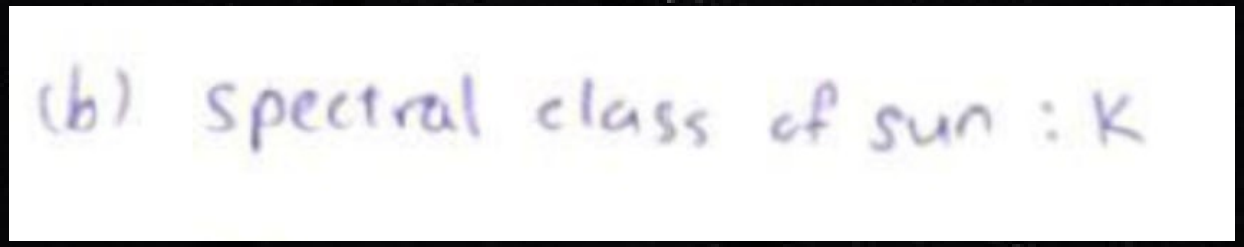
  Apparent magnitude is not the most important either... Consider: surface brightness, dust extinction along the way etc...

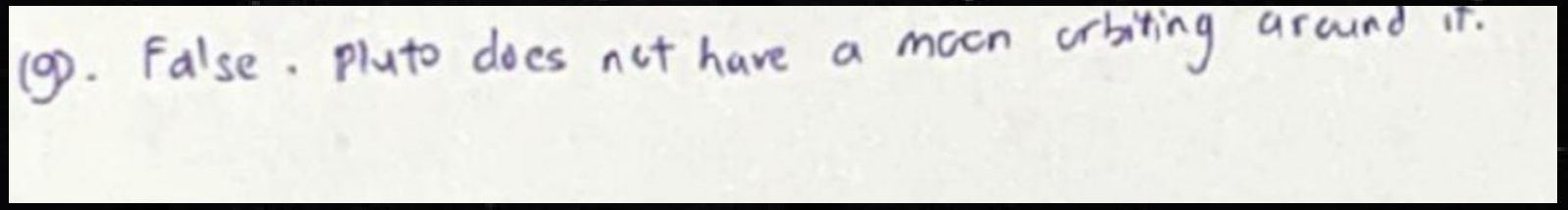


Short Answer Questions

- Lack of Basic Knowledge







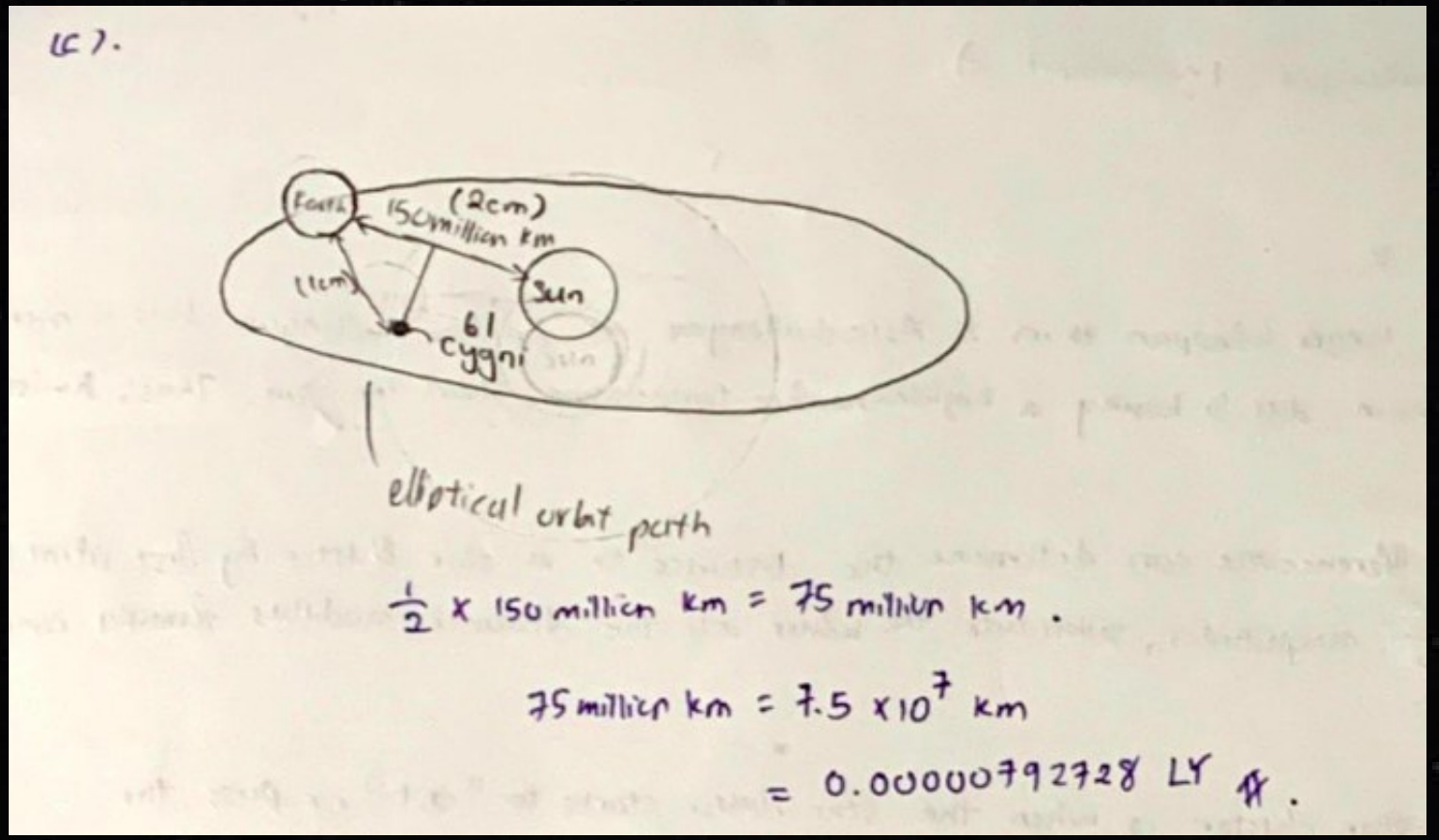
Junior Q2: History of Astro

Q Setter: Wei Zhong

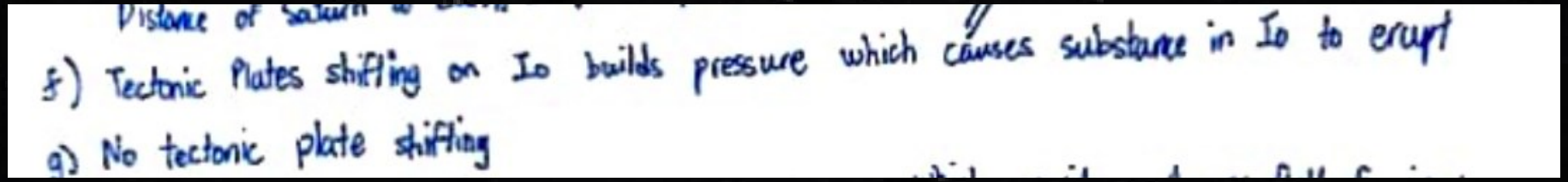
Common Mistakes

A) Most students apparently didn't read the question clearly. You are asked to label the direction of the motion of the **planet**, **epicycle** and **mark where retrogression is**. Most students missed out 2 or more of the elements, leading to penalisation. Do read instructions carefully in future.

C) Do you think it's possible for the star to be IN the solar system, squished



F) Io's volcanism is NOT a product of plate tectonics! Its internal heating is due to **orbital resonance** from its neighbouring moons and Jupiter, causing tidal forces to generate significant heat internally. This heat then causes spewing of internal materials directly, without action of plate tectonics.



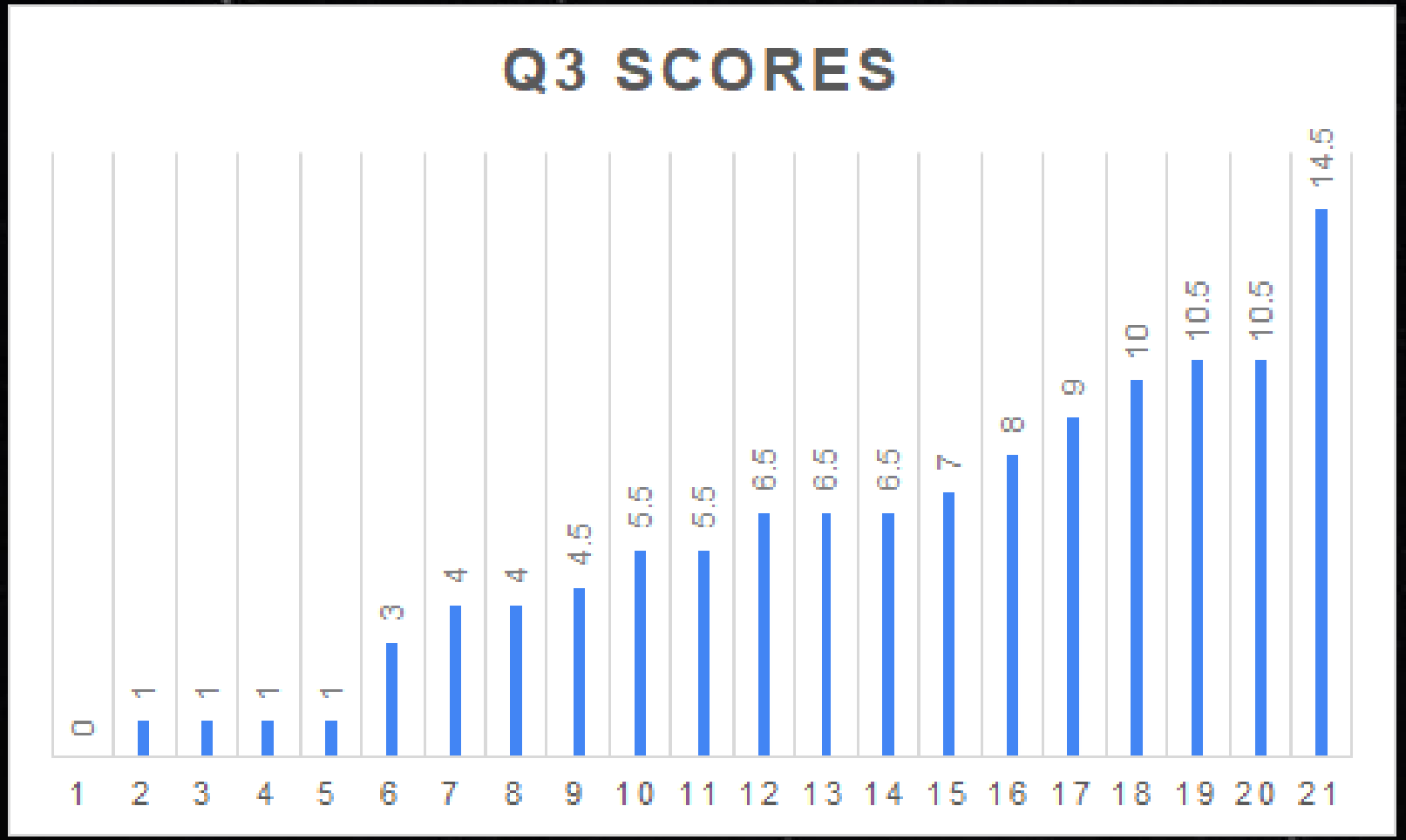
Common Mistakes

H) Many students stated that one advantage of reflectors is a wider field of view. This is NOT TRUE. The FOV that a telescope provides is dependent on the FL of the telescope (along with FL and AFOV of the eyepiece). Higher FL, lower FOV. I can totally have a refractor that is of higher FL and narrower FOV than a reflector.

Question 3

Setter: Xinjie

Q3: Stephan's Quintet



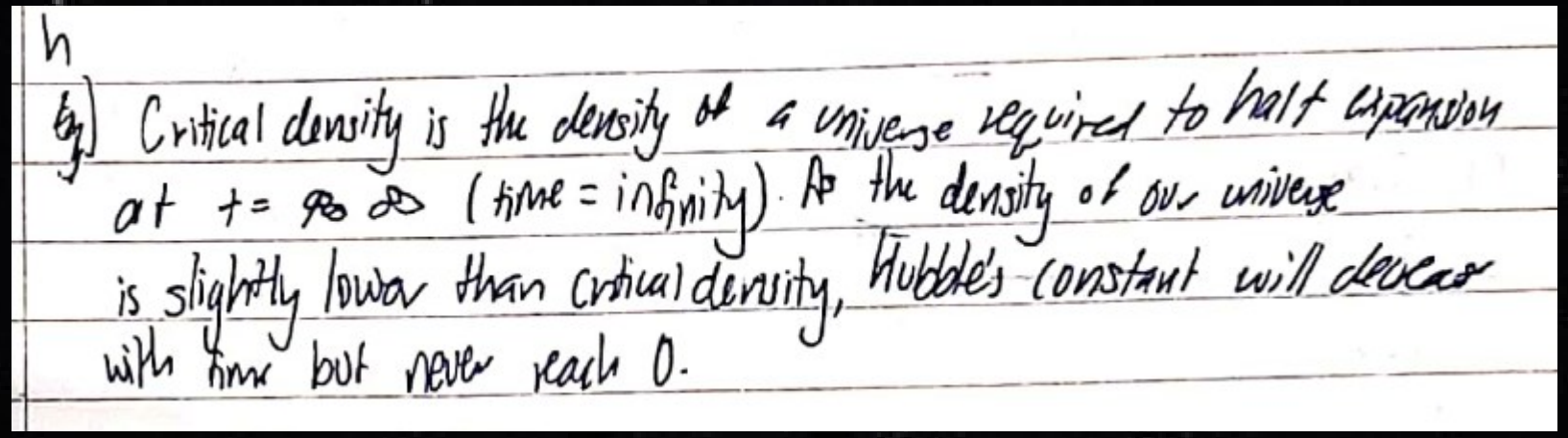
Median: 5.5

Mean: 5.69

Q3: Stephan's Quintet

- Most people know what is the Hubble's constant/critical density/redshift and so on but not their nuances/intricacies
- For example: Why is Hubble's "constant" not really a constant? How will it change with time in different universe models? And why does its value have non-negligible uncertainty?
- This resulted in lots of misconceptions and dubious statements…
- ...which show up in part h, the part that was the most poorly done

Q3: Stephan's Quintet


h

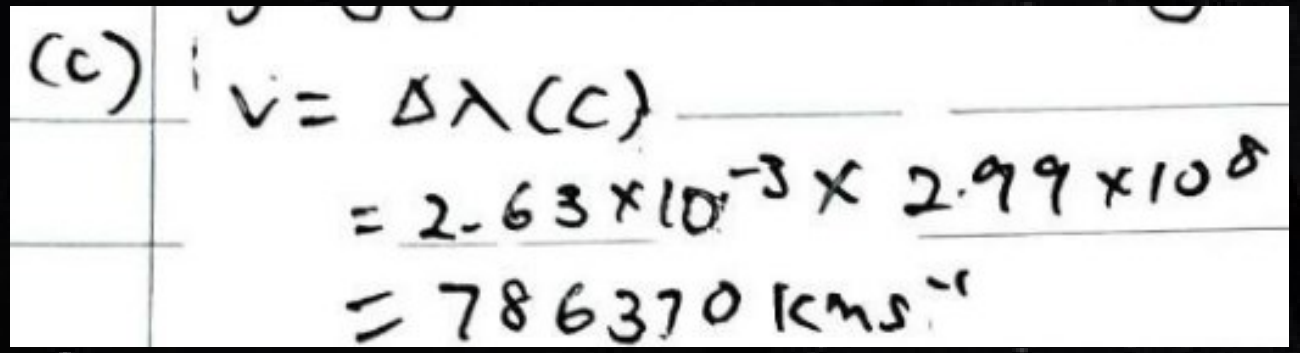
b) Critical density is the density of a universe required to halt expansion at $t = \infty$ (time = infinity). As the density of our universe is slightly lower than critical density, Hubble's constant will decrease with time but never reach 0.

Model Answer

Common misconception: The Universe is expanding at an accelerating rate. Therefore the Hubble's constant must be increasing as time tends towards infinity!

Q3: Stephan's Quintet

- Other mistakes are more minor but are equally worrying because they happen WAY TOO OFTEN
- For example: messing up your <u>units</u>



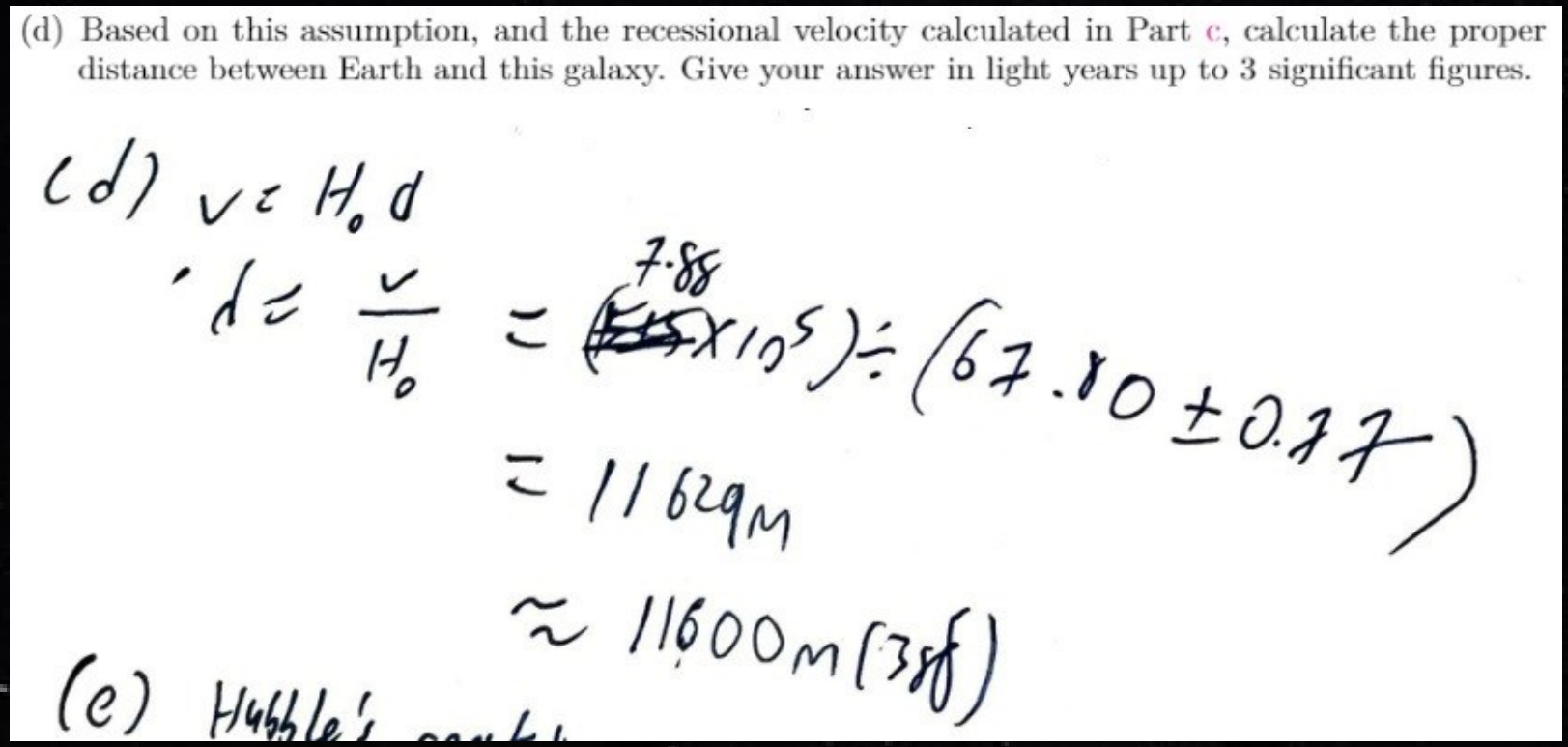
Speed of light, c =
$2.99 \times 10^8\ ms^{-1}$

NOT
$2.99 \times 10^8\ kms^{-1}$

P.S. It's literally stated in the formula booklet

Q3: Stephan's Quintet

This is what happens when you're not careful with your units...



(d) Based on this assumption, and the recessional velocity calculated in Part c, calculate the proper distance between Earth and this galaxy. Give your answer in light years up to 3 significant figures.

(d) $v = H_0 d$

$d = \frac{v}{H_0} = (7.88 \times 10^5) \div (67.80 \pm 0.77)$

$= 11629\text{M}$

$\approx 11600\text{M}$ (3sf)

(e) Hubble's

You started with the correct value of v!
How did you end up with that distance?

Q3: Stephan's Quintet

This is what happens when you're not careful with your units...

(f) Age of Universe $= \frac{1}{H_0} = \frac{1}{\frac{v}{d}} = \frac{d}{v} = \frac{11629\ \text{m}}{1.15 \times 10^5\ \text{m/s}}$

From (d), $d = 11629\ \text{m}$.

$\approx 0.1011\ \text{s}$

Q3: Stephan's Quintet

Final Comments and Tips:

- Read up more on Hubble's law
- Write your workings clearly (preferably with units clearly stated) so that you don't shoot yourself in the foot
- Skip ahead and skim through to check if there are manageable questions that you can do when you're stuck/short on time (Many teams completed half or less of the question and end up skipping the sub-questions that were supposedly easier to score)

Q4 (gravity and satellites)

Q Setter: Julian

Q4 (gravity and satellites) Error on my part

- When I set the paper, the orbital parameters of a geostat sat was calculated using a solar day ie 24 hours
- However during marking, a few teams calculated using sidereal day ie 23 hours 56 minutes 4 seconds, which is actually more accurate
- Hence I gave full marks and accepted both answers, as well as any error carried forward from the slightly different orbital velocity and altitude

Solar vs sidereal

e) $T = 24h = 84\ 86400s$

$r^3 = \frac{GM}{4\pi^2}(86400)^2$

Altitude $= 4.224 \times 10^7 km - 6.370 \times 10^3 km$

$= 35870$ km... shown

f) $v = \sqrt{\frac{GM}{r}}$

$v = \sqrt{\frac{6.67384 \times 10^{-11} \times 5.972 \times 10^{24}}{42240000}}$

$= 3071.8 ms^{-1}$

r_a of orbit $= 35870000m + 6.370 \times 10^6 m = 42240000m$

Calculating the velocity at perihelion of transfer orbit:

$\sqrt{(6.67384 \times 10^{-11})(5.972 \times 10^{24} kg)\left(\frac{2}{42240000m} - \frac{1}{24355000m}\right)}$

$= 1583.229646 m/s$

e) In geostationary orbit, $T = 23h\ 56min\ 4s$ (sidereal day)

$T^2 = \frac{4\pi^2 R^3}{GM}$

$h = R - r_\oplus$

$= 42163 - 6370$

$= 35793$ km (5sf)

f) In geostationary orbit $v = \frac{2\pi R}{T}$

$= \frac{2\pi (42163 \times 10^3)}{23 \times 60^2 + 56 \times 60 + 4}$

$= 3074.6$ m/s (5sf)

$R_{GEO} = 42163 \times 10^3$

$= 4.2163 \times 10^7 m$

$v_{Tx,a} = \sqrt{GM\left(\frac{2}{R_{GEO}} - \frac{1}{a}\right)}$

$= \sqrt{6.67384 \times 10^{-11} \times 5.97}$

$= 1586.0$ m/s (5sf).

Q4 (gravity and satellites)
Common mistakes

Marker's note: Red underline
represent correct answering point

1. Missing parts in submission

- Some teams submitted incomplete answer scripts, where the missing parts don't even show up in the pdf
- So idk if you genuinely left it blank and skip, or if you forgot to attach it to your answers and is still hanging around in your camera roll
- Therefore ensure that the pdf you submit has all the parts that you attempted
- To reduce doubt, just write the question no. of the parts that you skip and leave them blank (but at least write something logical, still can get 0.5 marks)

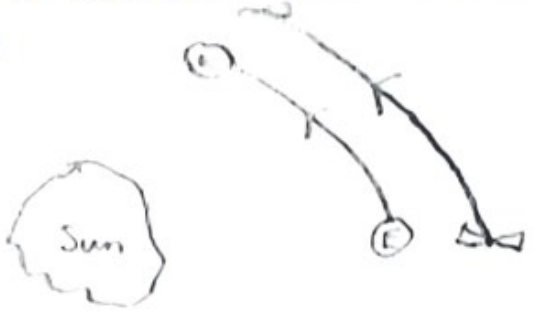
2. Know what geostationary orbit is, but not geosynchronous orbit

a) Geostationary Orbit is where a satellite's orbital velocity is equal to Earth's rotational velocity, so the satellite appears to be in the same position in the sky

0.5

Geosynch Geosynchronus Orbit is where a satellite's orbit around the Earth appears to form an orbit around the sun as well

?



a) Geostationary orbiting satellites are always at the zenith of a specific geographical area of earth while geosynchronous orbiting satellites orbit in the same direction as earth, with a higher velocity than the rotation of earth.

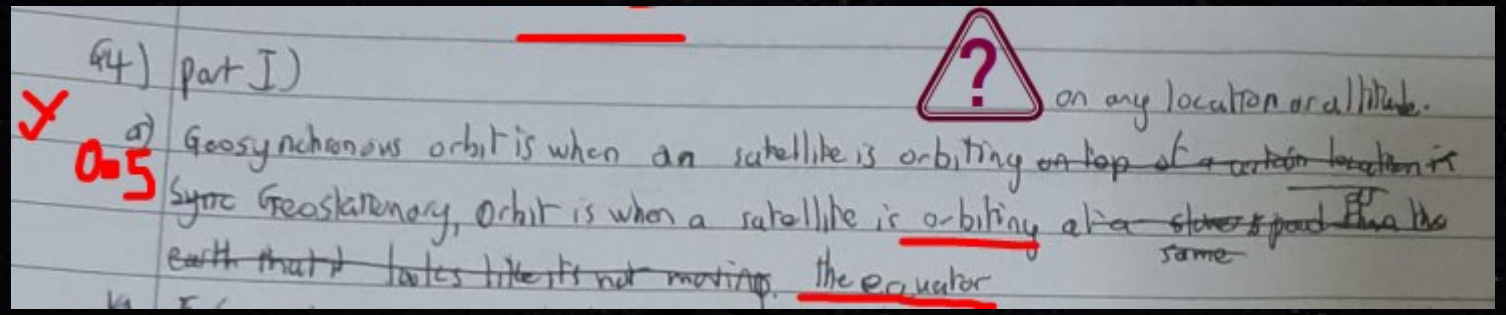
0.5

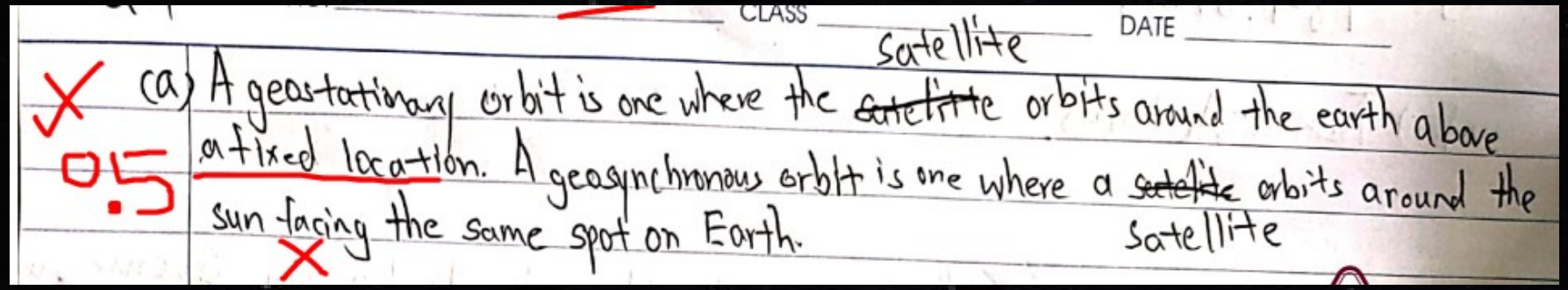
a) A geosynchronous orbit moves along with the rotation of Earth at the same rotational period of Earth while a geostationary orbit need not necessarily orbit in the same direction. orbit allows an object to seemingly stay at the same point as viewed from earth

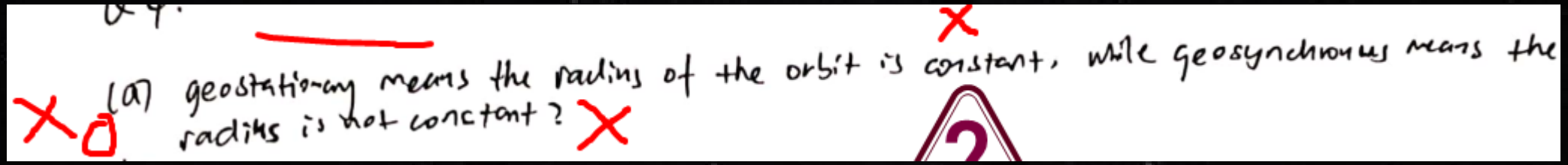
0.5

(b)

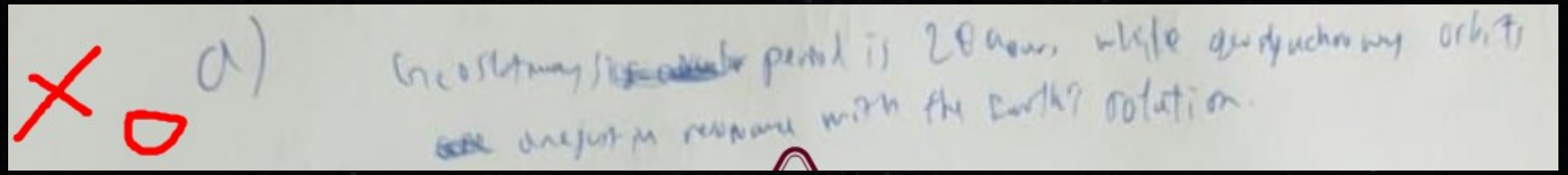
2. Know what geostationary orbit is, but not geosynchronous orbit

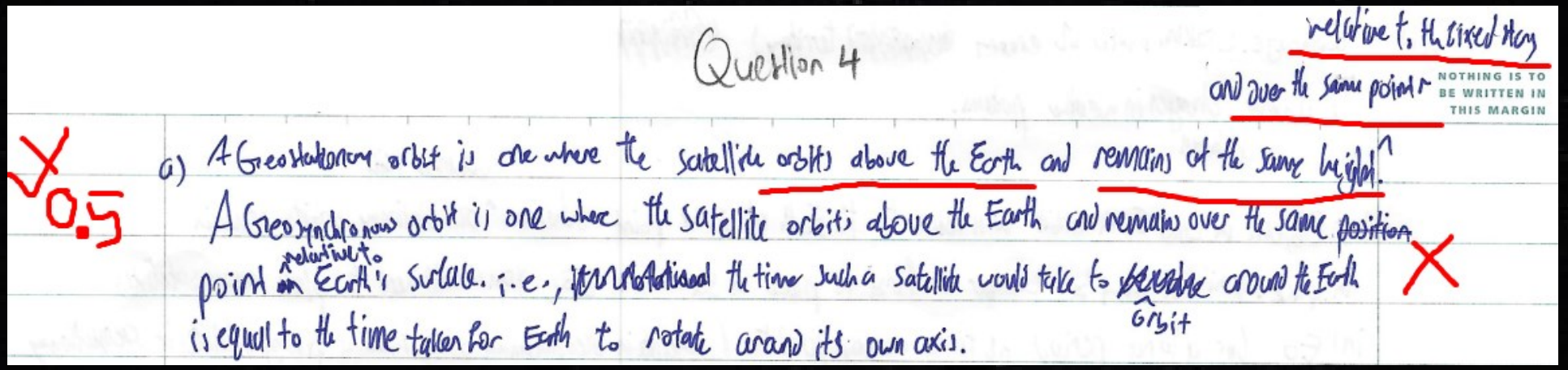


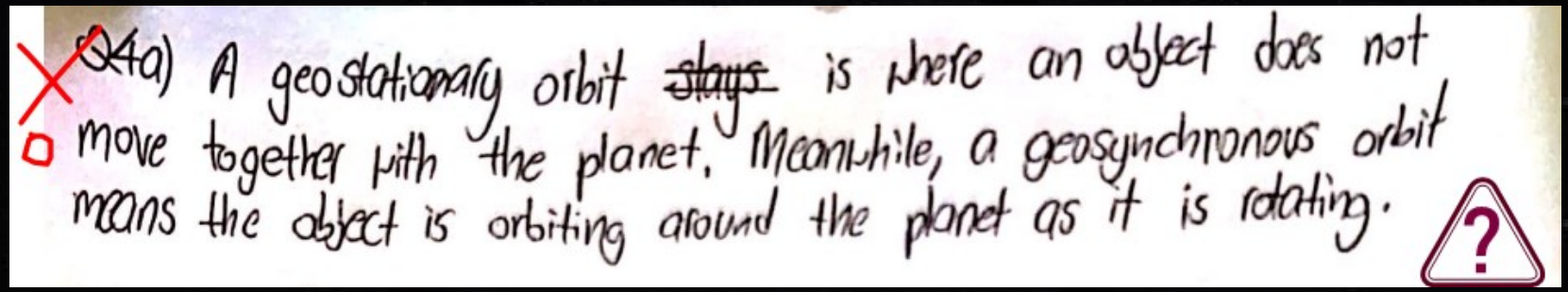




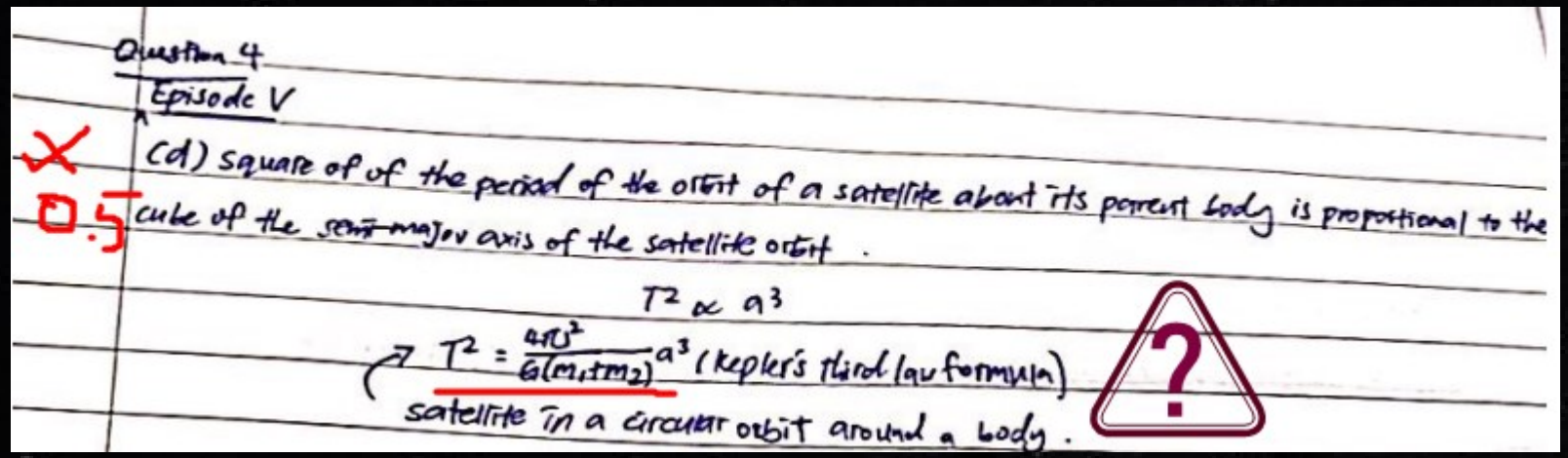
2. Know what geostationary orbit is, but not geosynchronous orbit

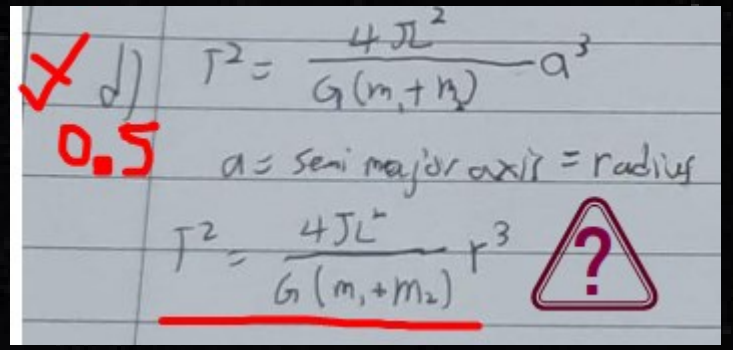


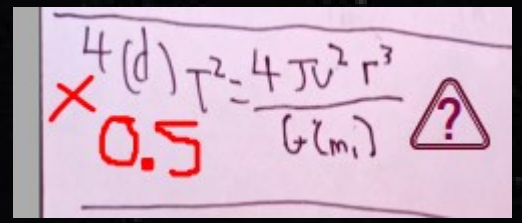


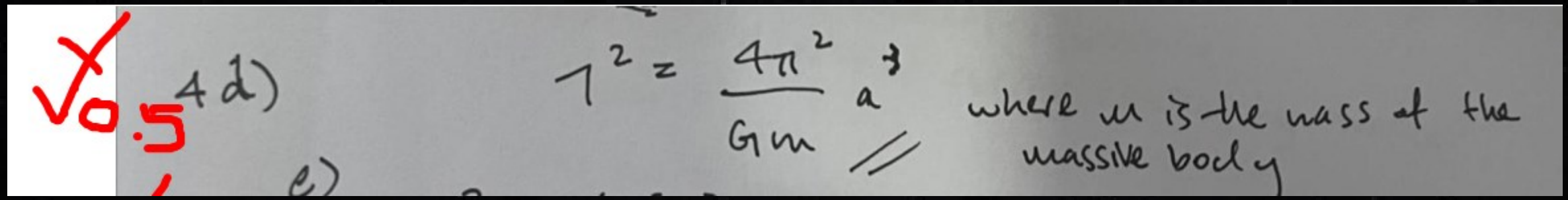


3. Copy-paste the formula book and call that derivation









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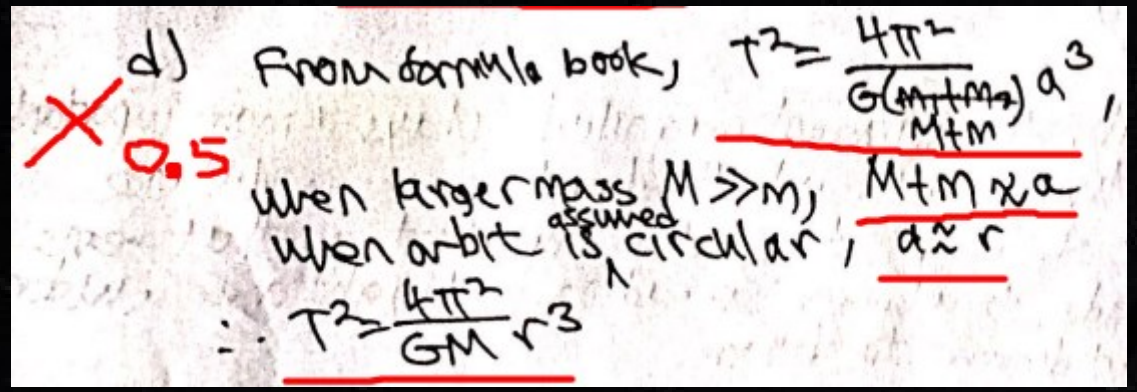
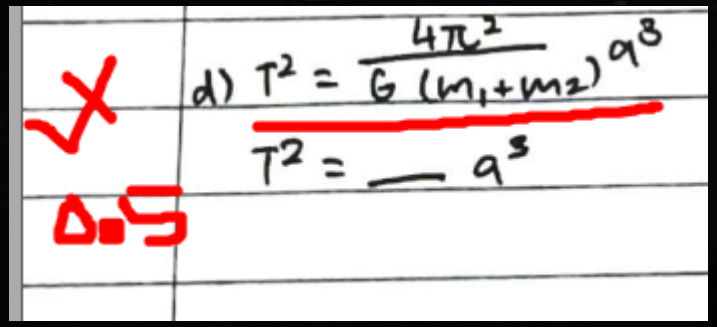
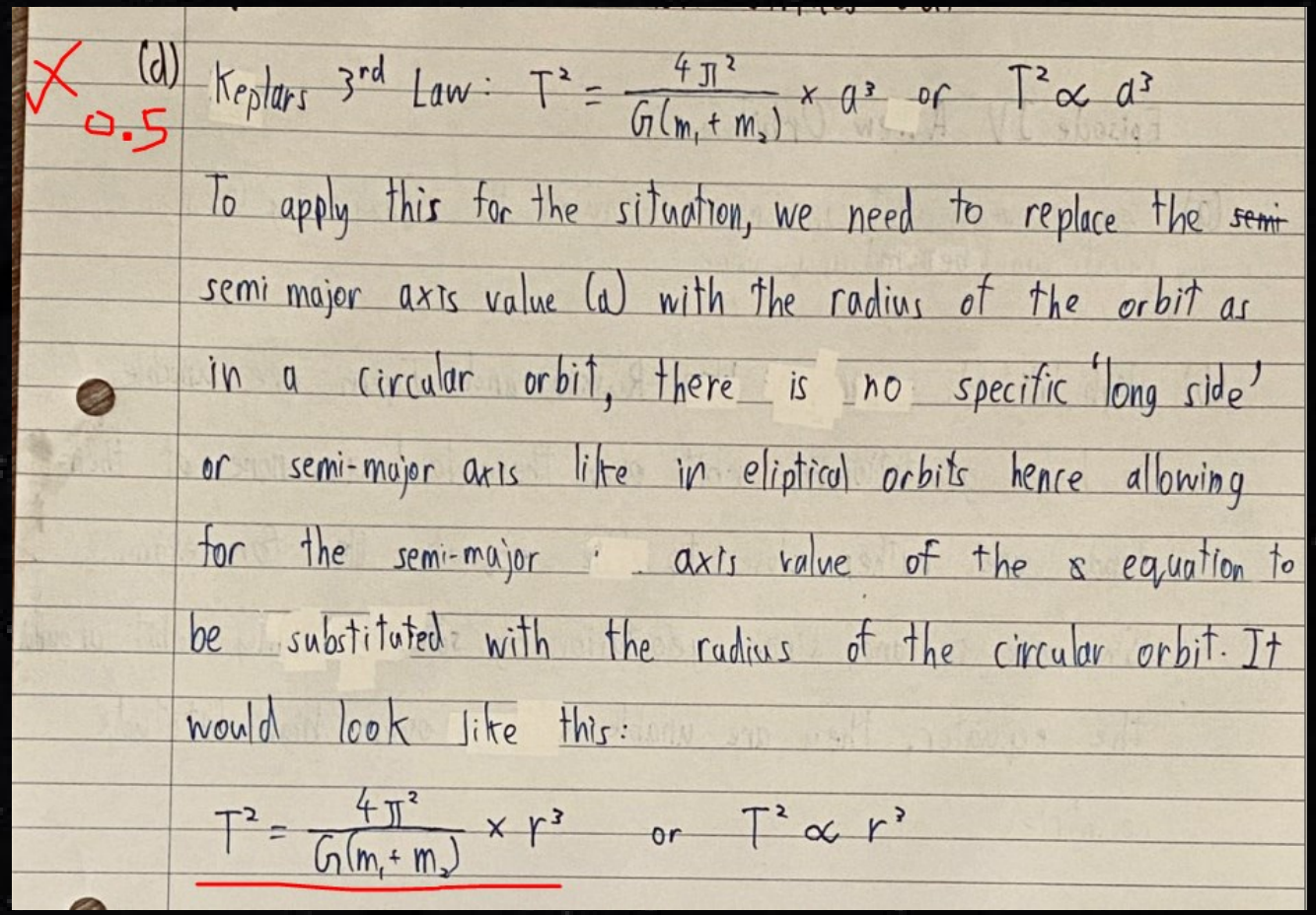
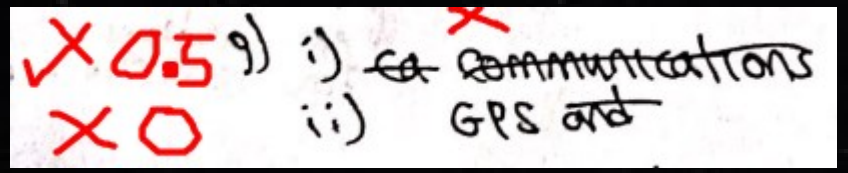
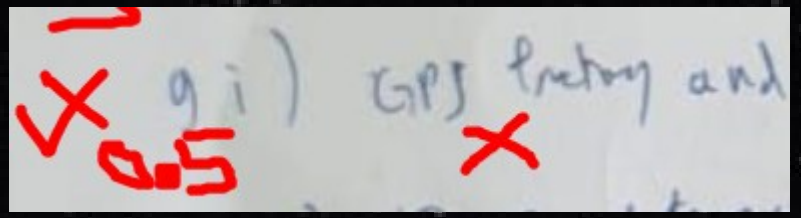


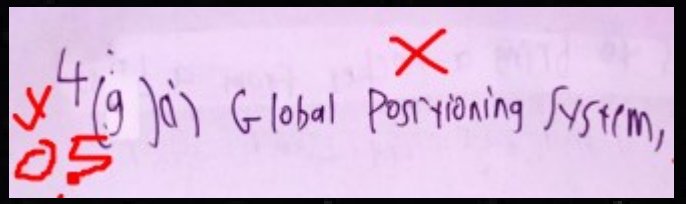


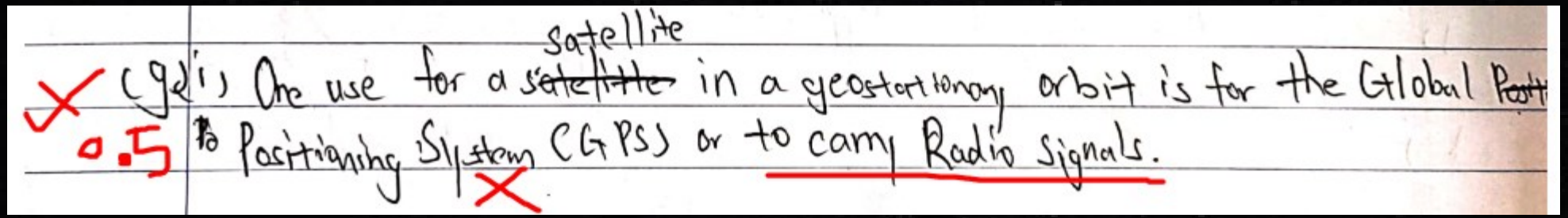


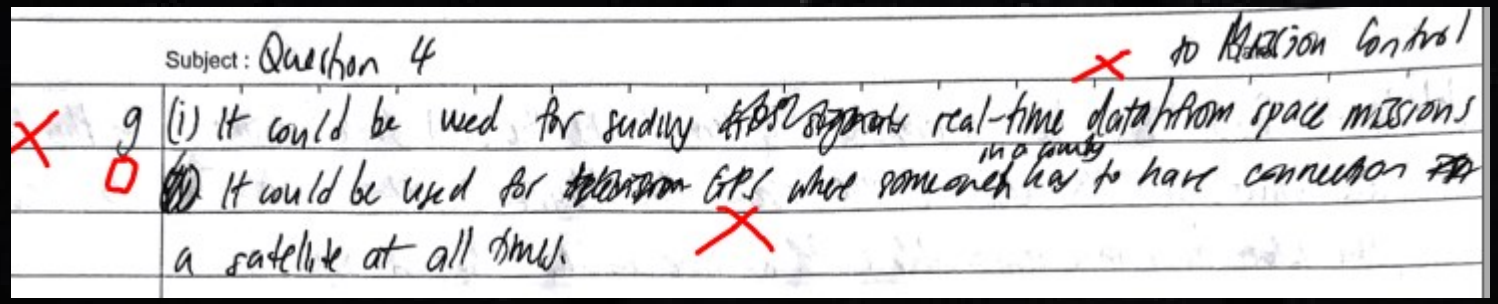
5. There are no GPS sats in geostat orbit. They are in MEO, orbiting twice a day



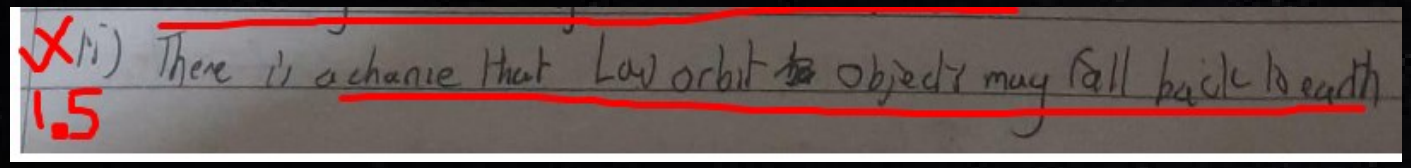


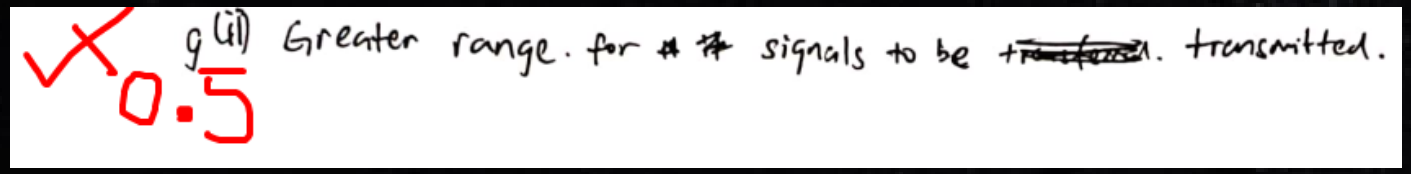


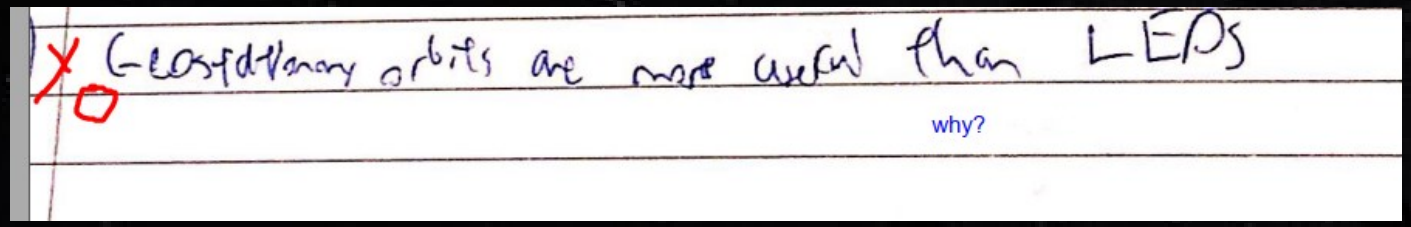


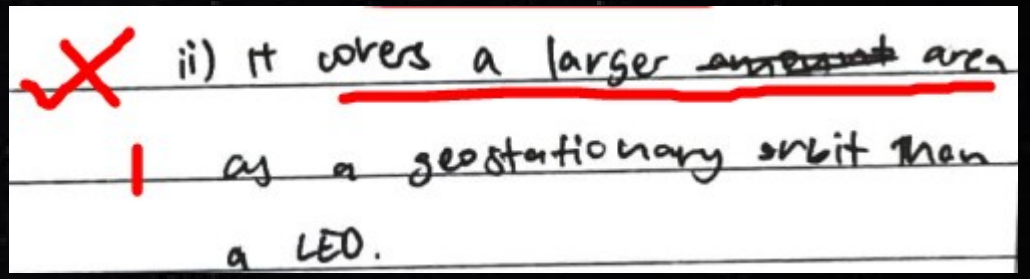


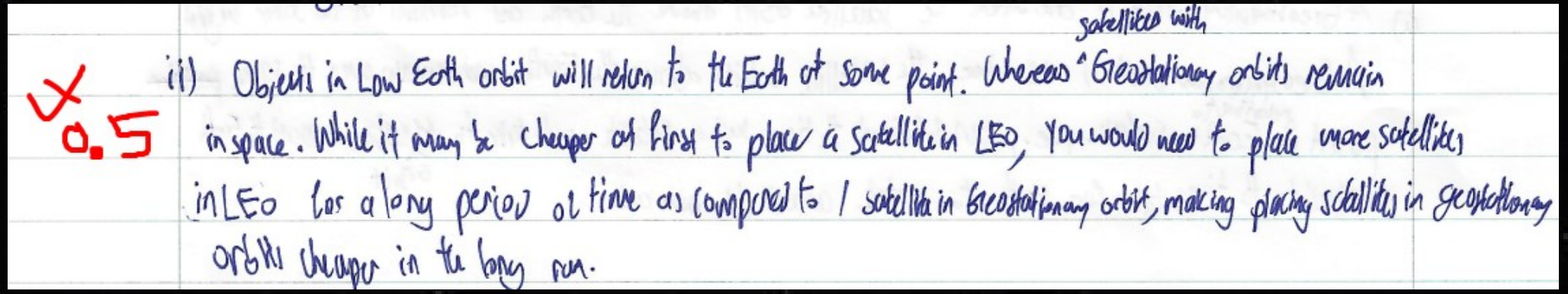
6. Explained why HEO (but not geostat specifically) are better than LEO











7. Simply subtracted geostat velocity and LEO velocity

j) ~~[illegible]~~

X ~~[illegible]~~

O $\Delta V = 7848.7\,ms^{-1} - 3071.8\,ms^{-1} = 4776.9\,ms^{-1}$

$\Delta V =$ ~~7848.7~~ $v_f - v_i$

$= 3071.8 - 7848.7$

$= -4776.9\,ms^{-1}$.

X

$\Delta v = v_f - v_i$

$= 10664.2\,m/s - 7848.7\,m/s$

$= 2815.5\,m/s$

$3070.9 - 7848.7 = -4777.8$ (s.f.)

$= -478$ (3s.f.)

$\therefore \Delta V =$ ~~[illegible]~~ $-478\,m/s$

X (i) $v^2 = GM\left(\frac{2}{42239727.97} \div \frac{1}{35869727.97}\right)$

O

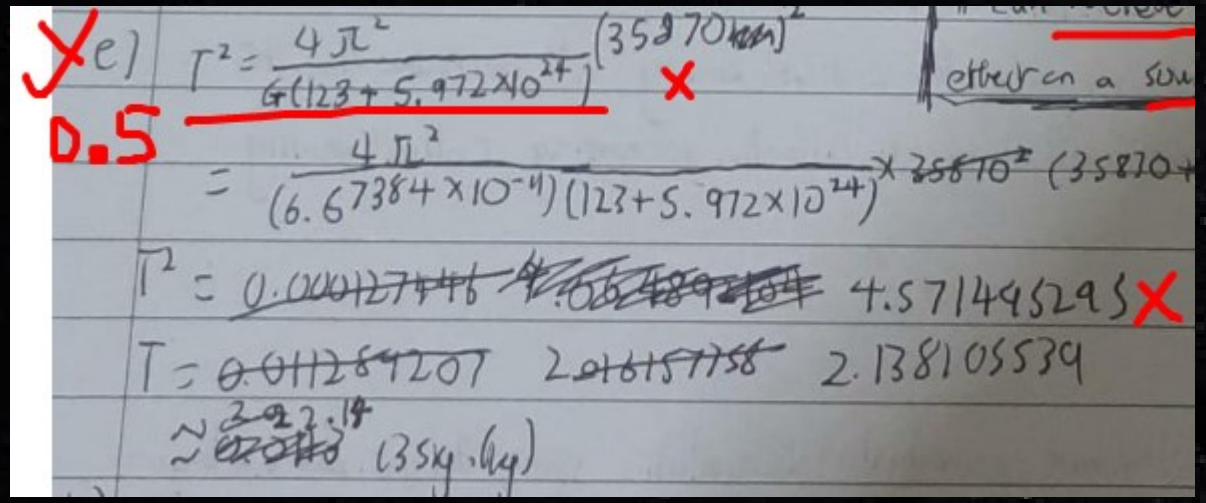
$= 7760047.956$

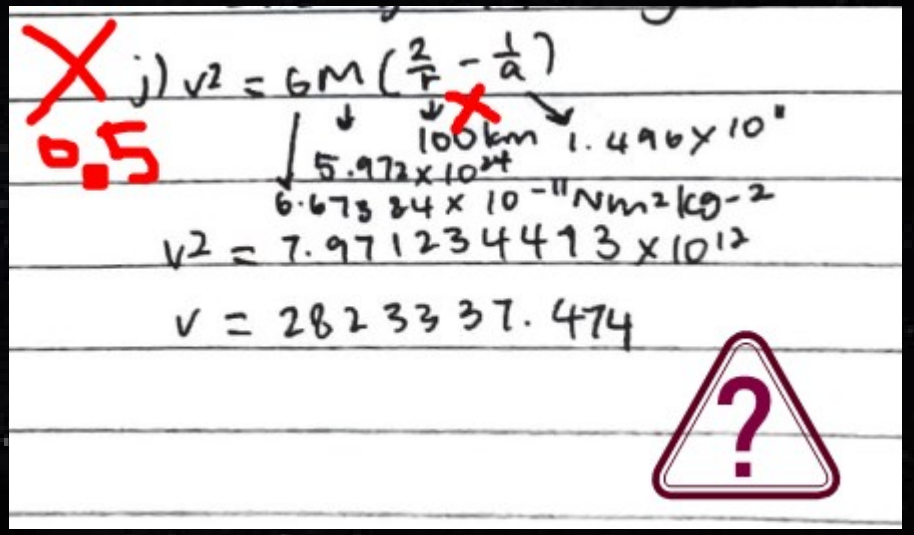
$V = 2785.686$ (3dp)

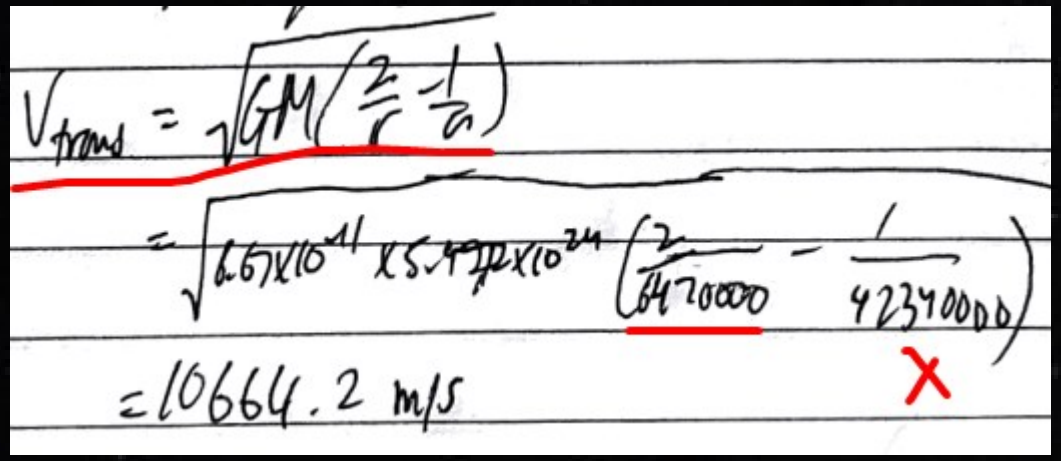
$\Delta V = 7848.7 - 2785.686$

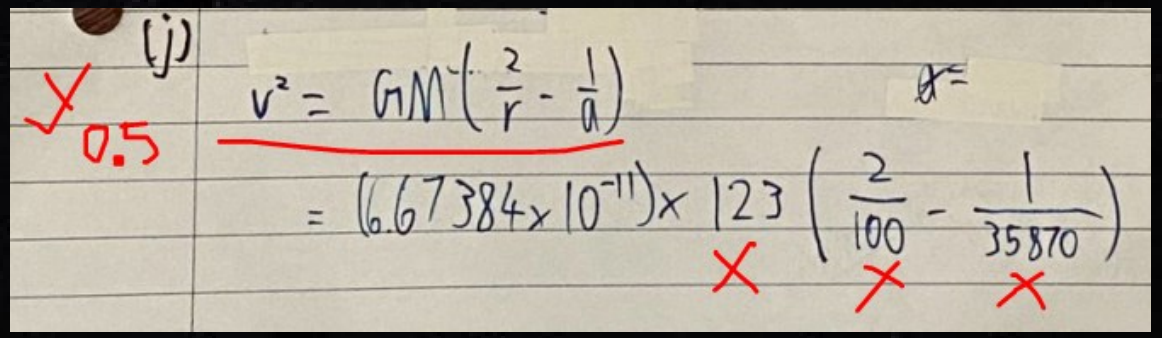
$= 5063.014\,ms^{-1}$

8. Forget to convert altitude to orbital radius

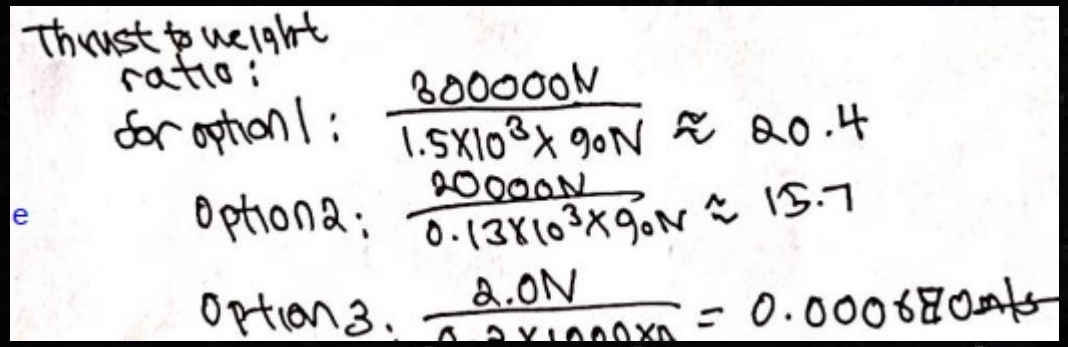


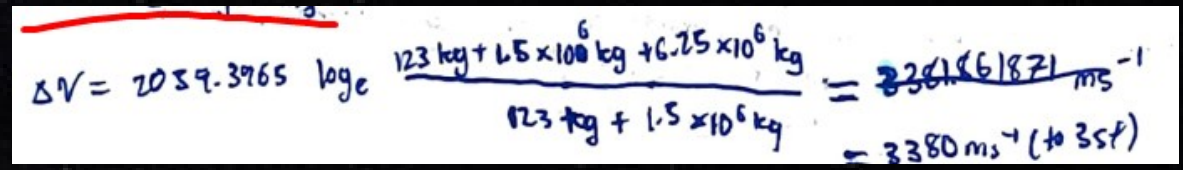


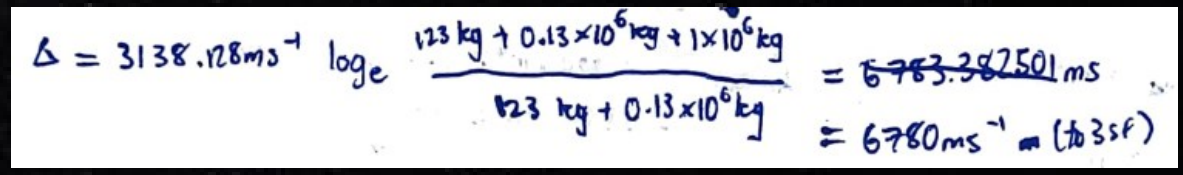


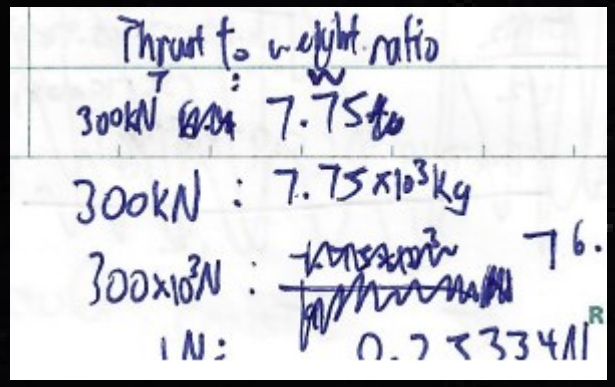


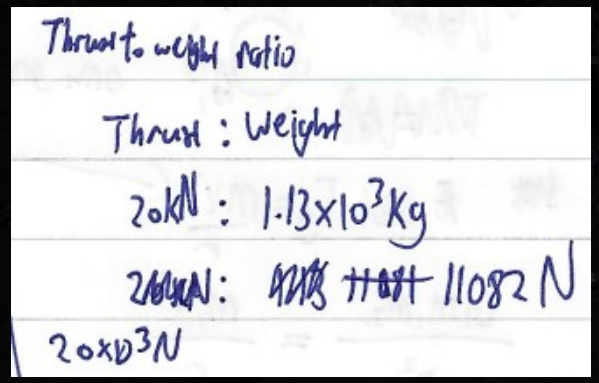
9. Forgot include mass of satellite or fuel

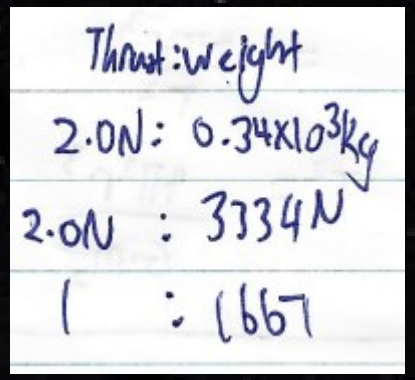


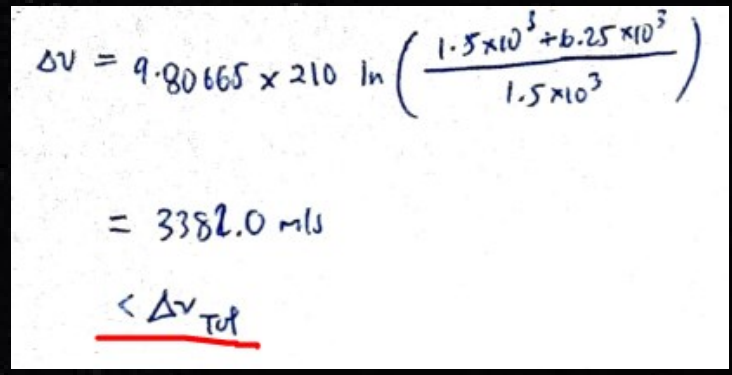


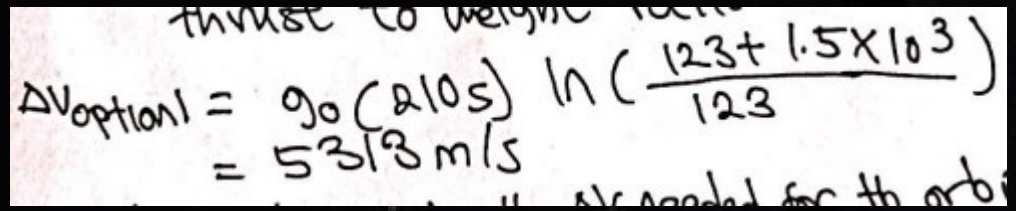


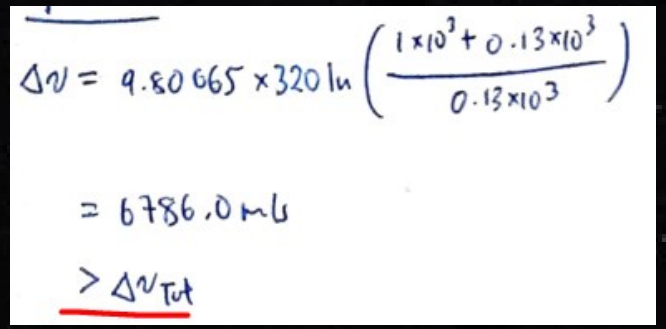


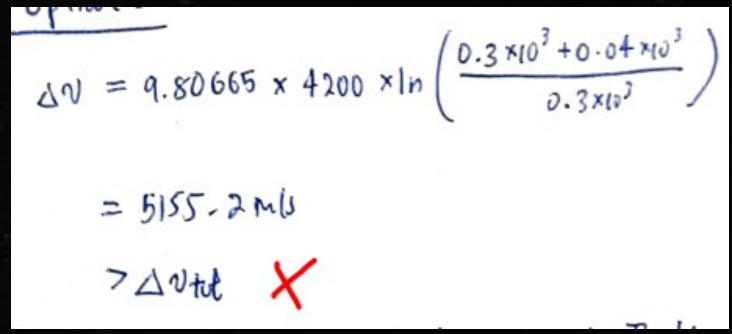




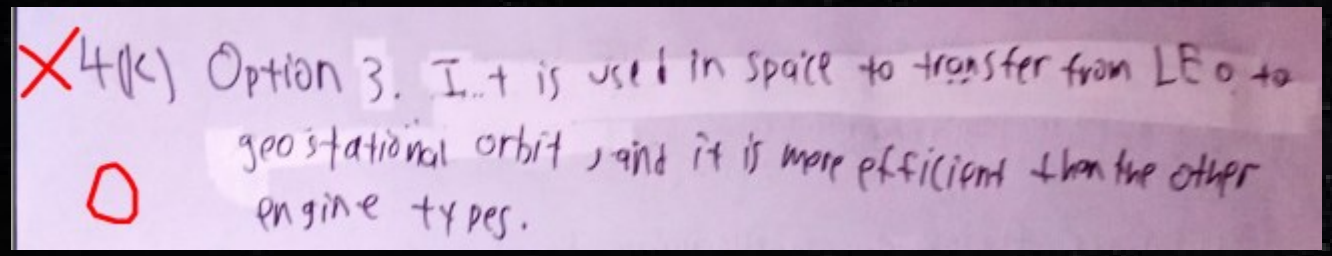


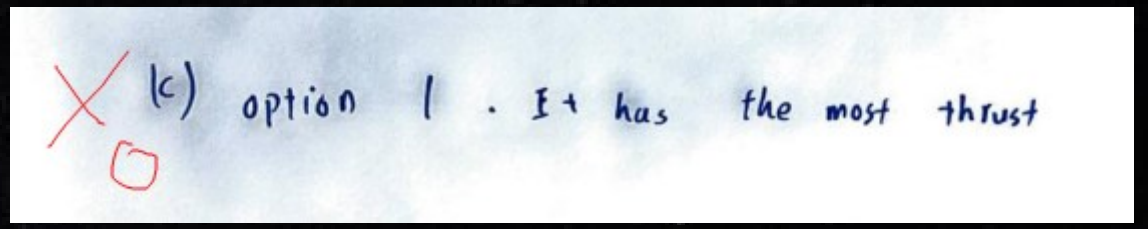


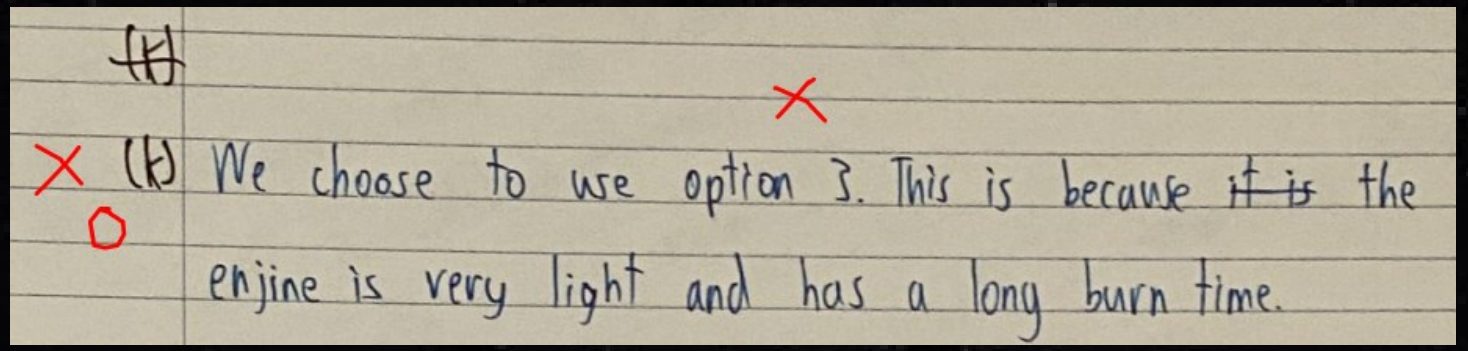


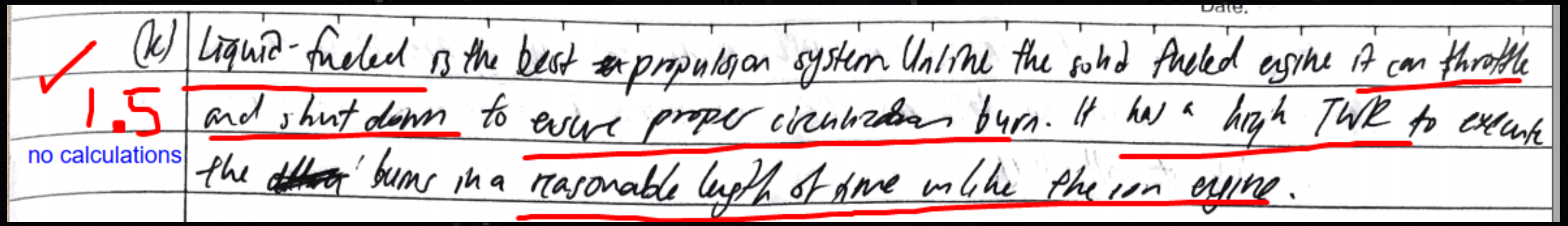


10. Reached conclusion without calculations





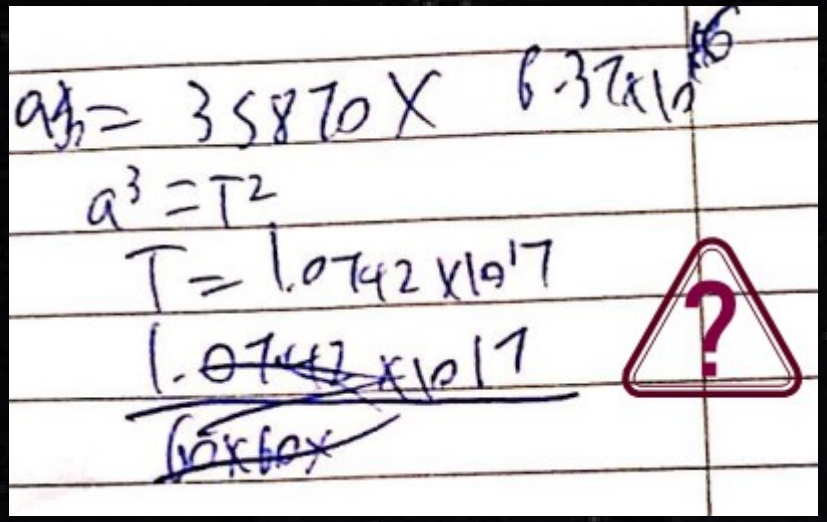




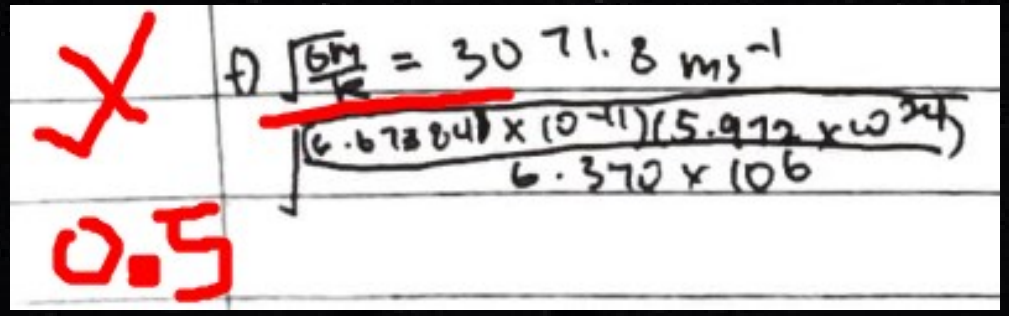
Q4 (gravity and satellites)
One-off mistakes

$$T^2 \propto a^3$$

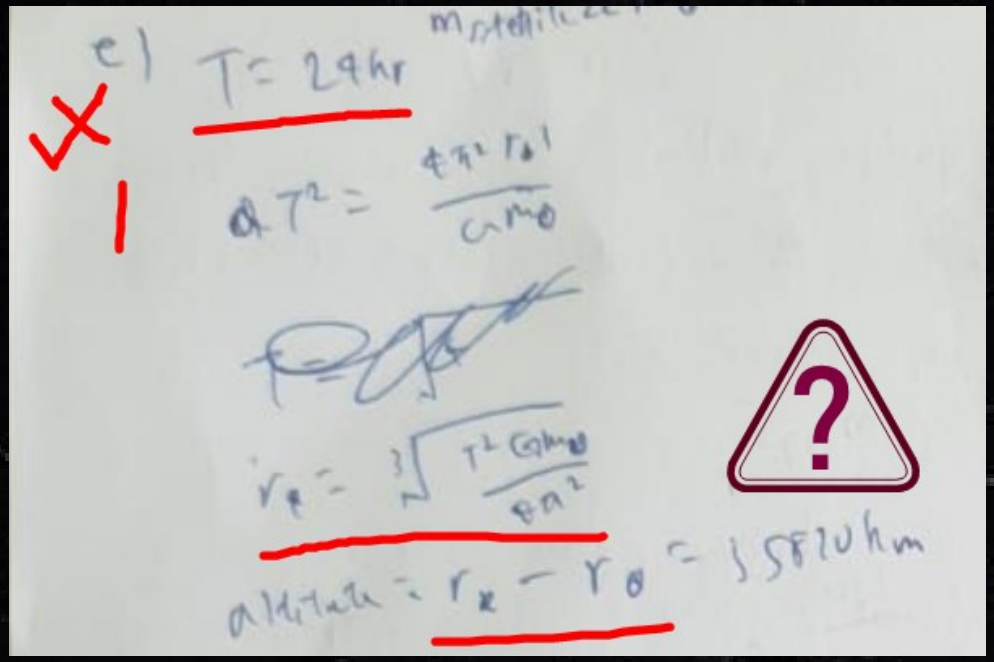
1. Mistook proportional as equal



2. Supposed to calculate and show the given value but you equate your formula to it



3. Showed formulas but numbers magically fly out

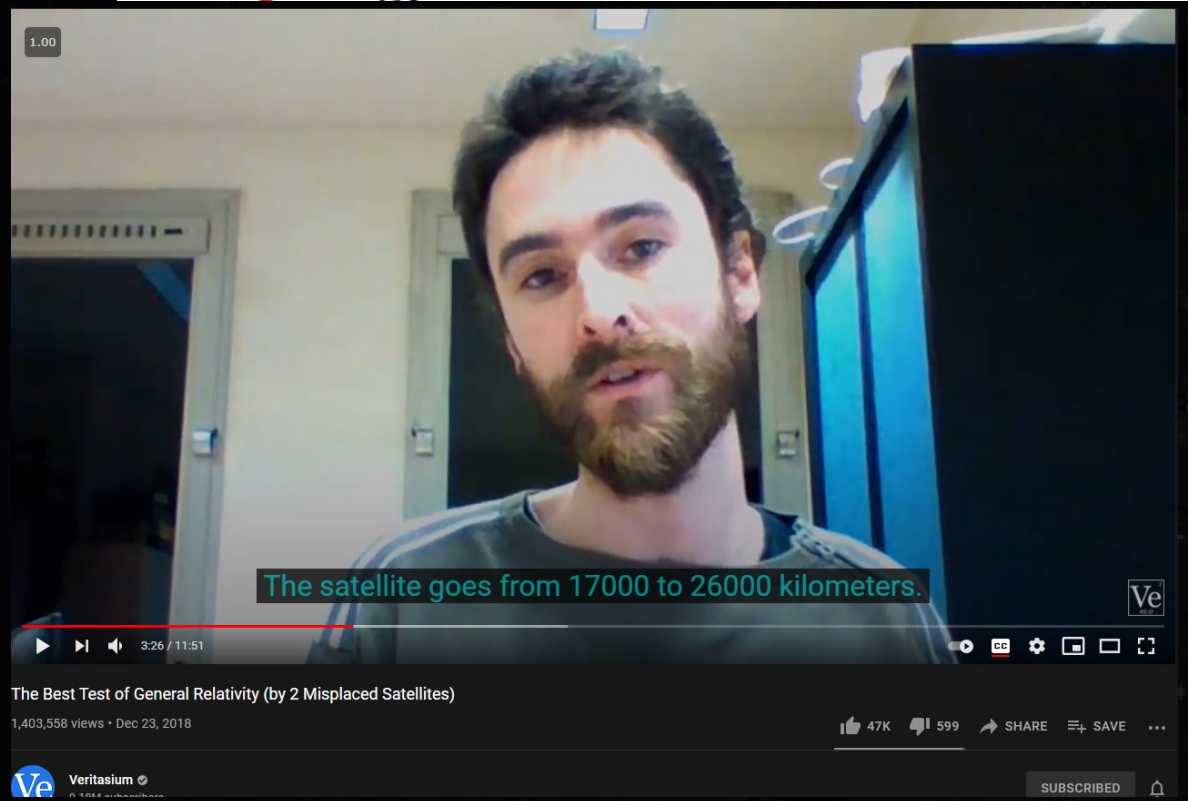


5. The satellites you cited are in an elliptical MEO, and the expt does not work in circular geostat

X
0.5

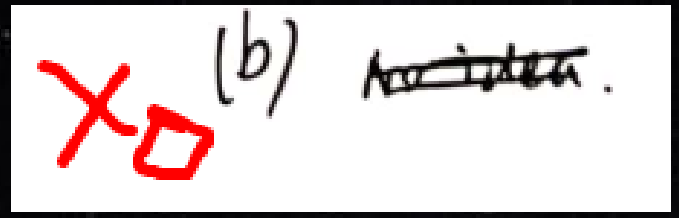
g (i) ~~Fo measure~~ ~~Expl~~. To be used as an experiment to prove General Relativity. (Veritasium video). X

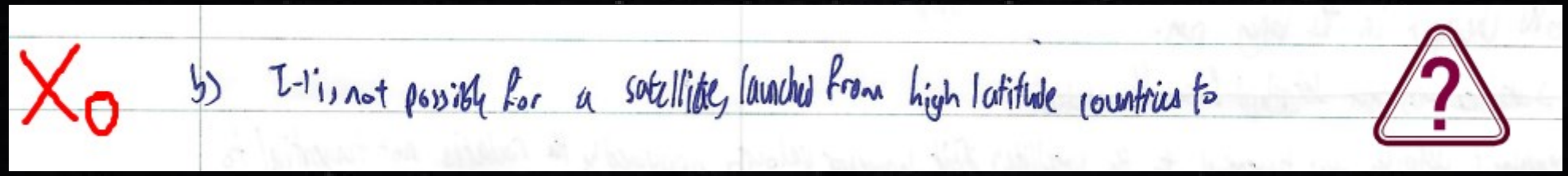
2. Transmit signals just like what other satellites do.

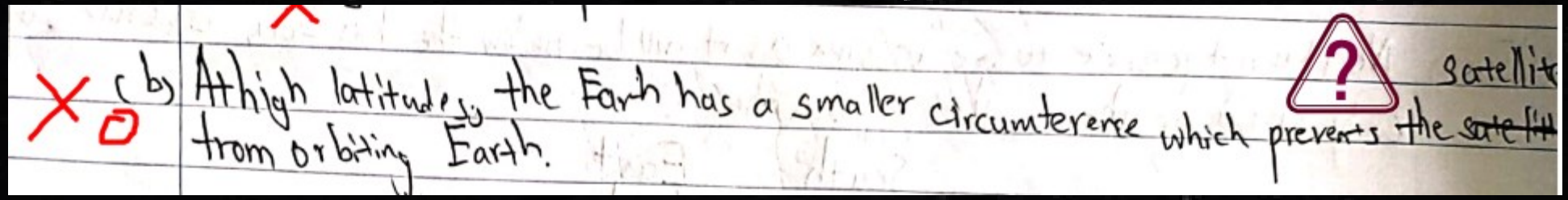


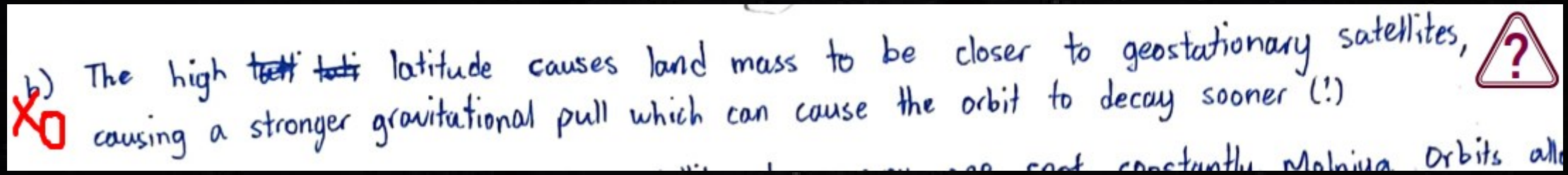
Q4 (gravity and satellites)
Comedy answers

Q4b. Why high lat countries got no geostat sats?

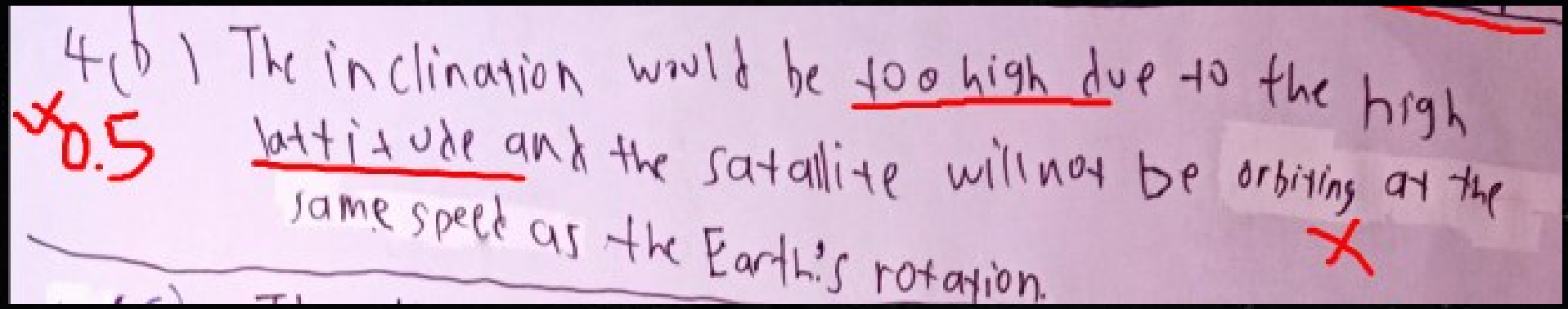


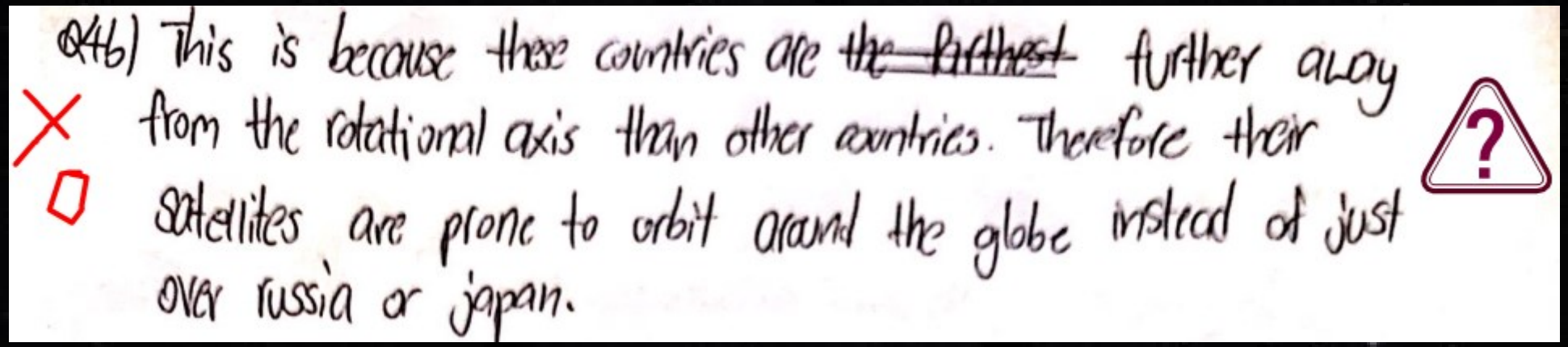






Q4b. Why high lat countries got no geostat sats?





Q4c. Why Molniya orbits work like geostat?

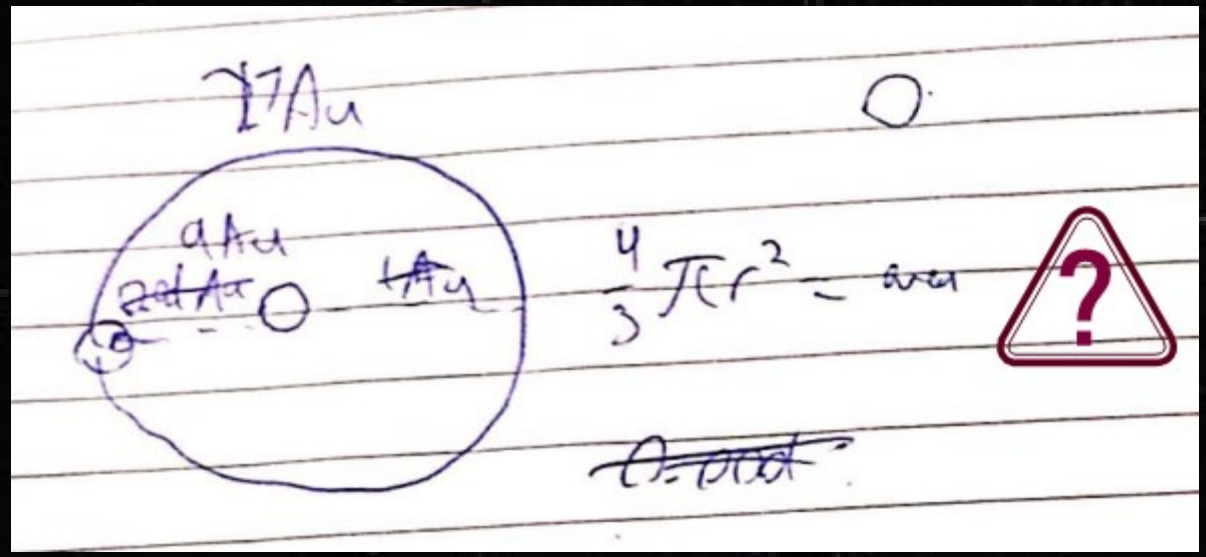
X O Q4c) Satellites following the Molniya orbits will be less affected by the gravitational pull of the Earth at its high latitude areas.

X O c) Because these orbits allow for formation to be trasferred from one end of the Earth (the Southern Hemisphere) to the other end of the Earth (Northern Hemisphere)

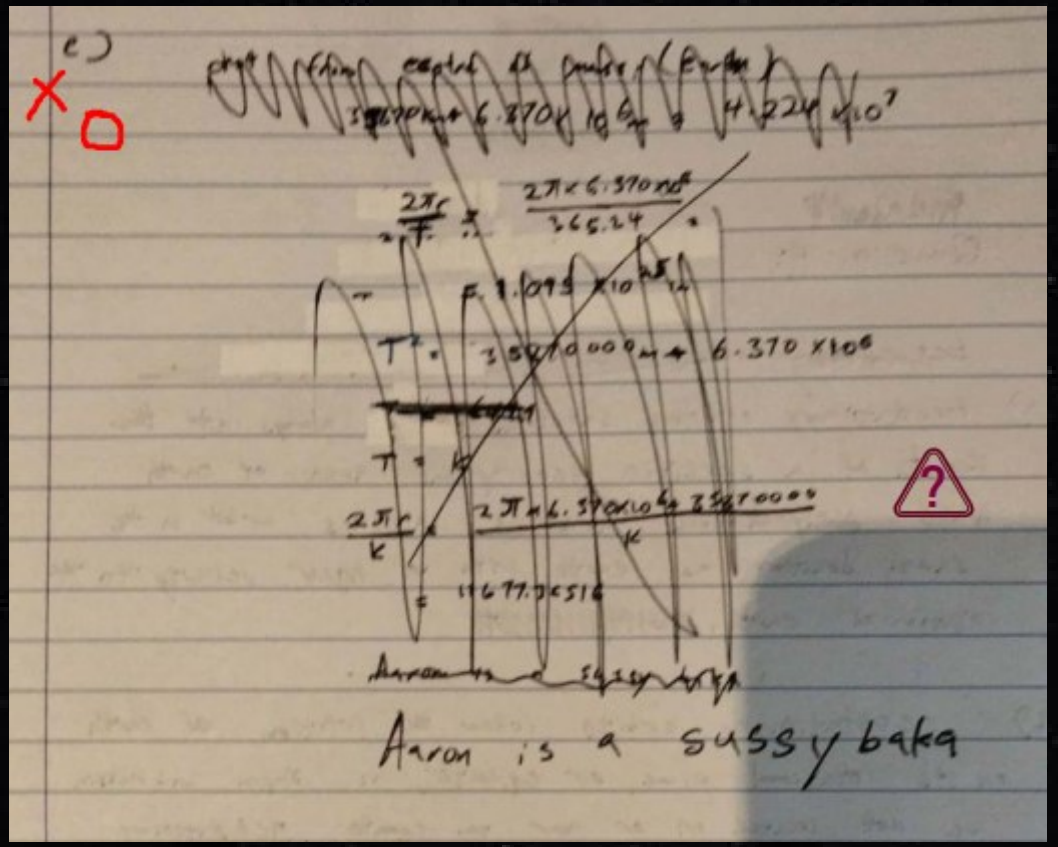
X O (c) It works just like a normal satellite except it travels in an elliptical orbit instead of a circular one..

X O c) Satellites are mostly used to send and receive electromagnetic radiation, thus aiding in communication. As all electromagnetic radiation travels at C, so any the difference in height is negligible when transmitting and receiving electromagnetic radiation signals.

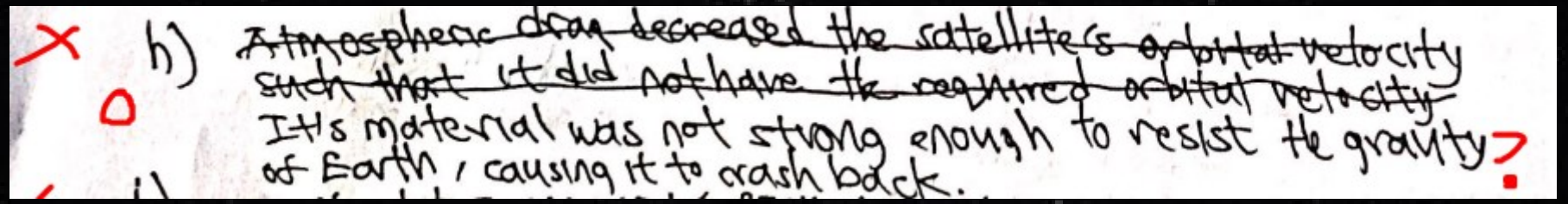
Q4d. Derive Kepler's 3rd law



Sussy baka



Q4h. Why did Jeblink 1 fall back to Earth?



Material not stronk enough to resist gravity of Earth…..

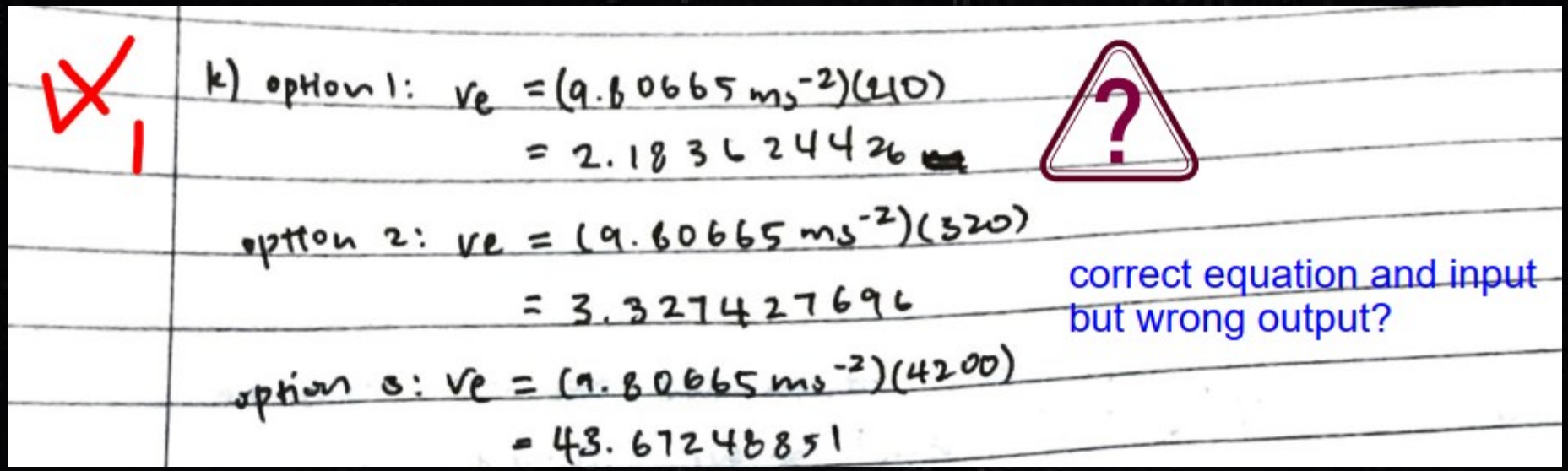
X O j)

X O (c) option 1 . It has the most thrust

X O (j) $784.87 ms^{-1}$

(k) Taurus Actuus.

RIP math


k) option 1: $v_e = (9.80665\ ms^{-2})(210)$
$= 2.18362446$
option 2: $v_e = (9.80665\ ms^{-2})(320)$
$= 3.32742769$
option 3: $v_e = (9.80665\ ms^{-2})(4200)$
$= 43.67248851$
correct equation and input but wrong output?

Question 5 Obs

Q Setter: Nicholas T

Summary

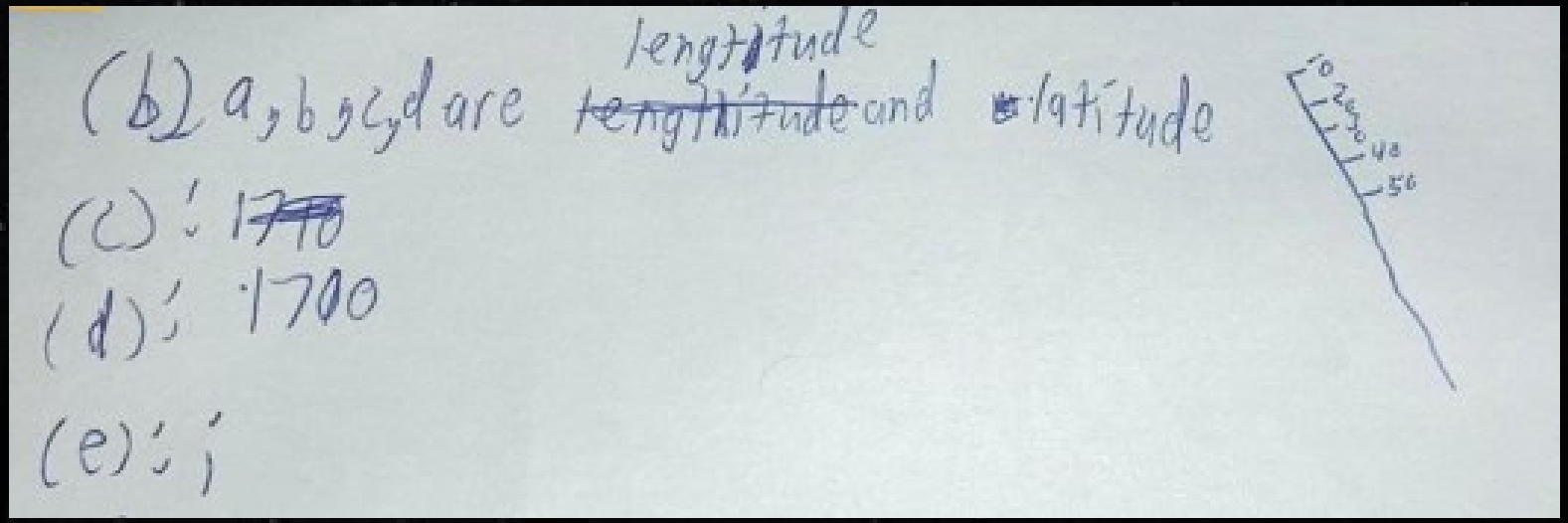
- Not too many funny things were observed.
- Some of you complained that this question was a scam and pleaded with the QM to never set the question again...
  - For reference, the team/person who did that scored exceptionally well
- Some people did not even attempt this question...

Summary

- Nice drawings

Summary

- Cardinal Directions are longtitude and latitude?



Senior Team Round

Senior SAQ (Q1)

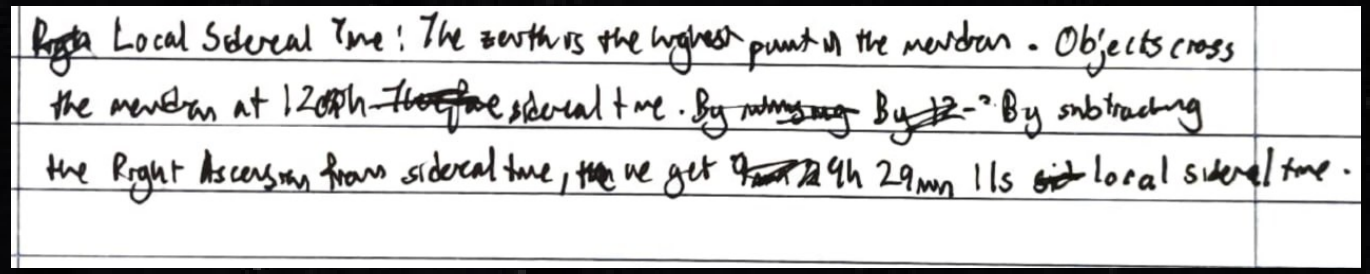
Q Setter: Nicholas P and Nicholas T

Short Answer Questions

- It was supposed to be easy.... Except that it killed quite a lot of you.
- No calculations were required... Except that some of you decided to do it anyway.

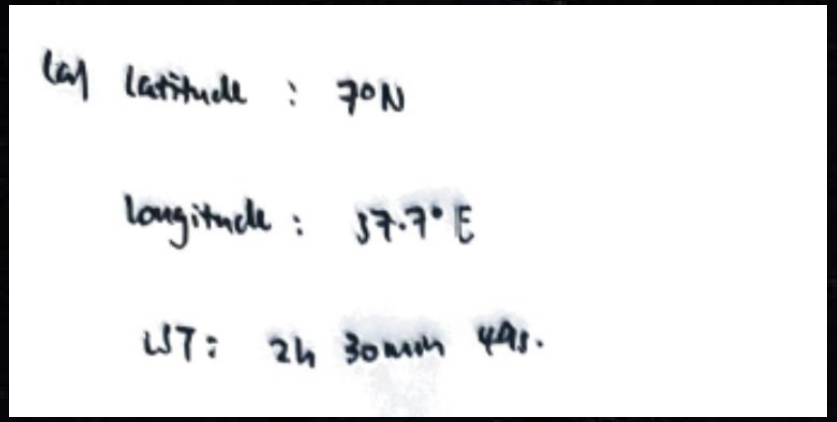
Short Answer Questions

- Do not overthink the question
  - Marker's comment: how did you come up with LST= 9h29m11s??



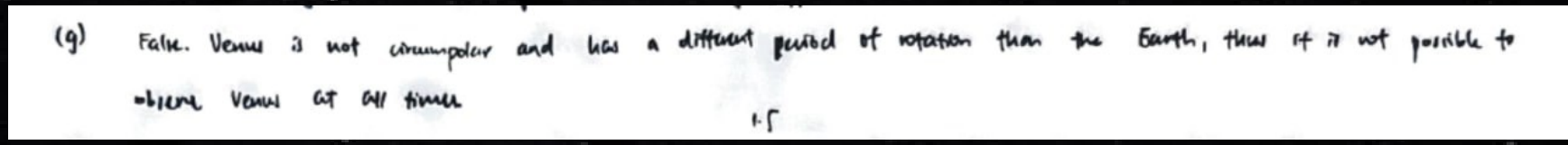
Short Answer Questions

- Do not magic out answers.

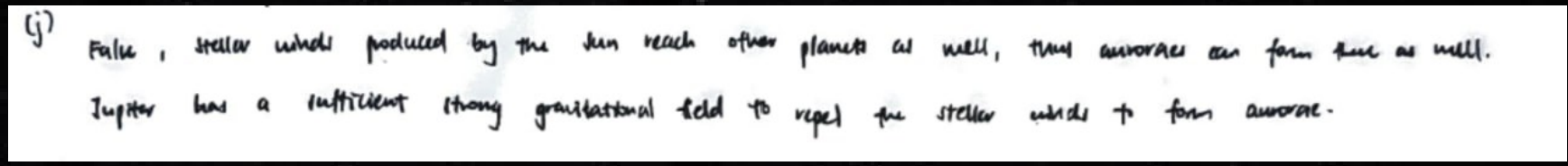

(a) Latitude : 70N

Longitude : 37.7°E

UT: 2h 30min 49s.


(g) False. Venus is not circumpolar and has a different period of rotation than the Earth, thus it is not possible to observe Venus at all times

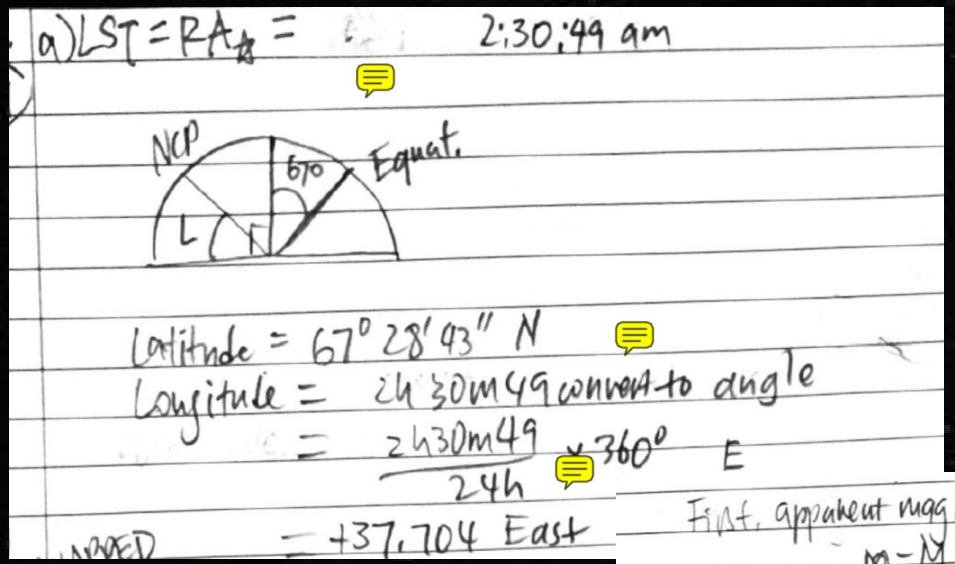
Venus is not circumpolar and has a different period of rotation than the Earth, thus it is not possible to observe Venus at all times....


(j) False, stellar winds produced by the sun reach other planets as well, thus auroraes can form there as well. Jupiter has a sufficient strong gravitational field to repel the stellar winds to form aurorae.

Stellar winds produced by the Sun reach other planets as well, thus auroraes(sic) are form (sic) there as well. **Jupiter has a sufficient (sic) strong gravitational field to repel the stellar winds to form aurorae**.

Short Answer Questions

- Do not do calculations...
  - Wrong calculations



Name	X Astrochallengae
Right Ascension	2h 30min 49s
Declination	67°28′43″
Distance	142ly
Apparent Magnitude	4.5
Absolute Magnitude	1.31

Table 1: Information regarding X Astrochallengae.

(b) Without using Table 1, suggest a method to determine the distance to this star system. Explain why your suggested system is appropriate. [3]

First, apparent mag (m) and absolute mag (M) differ by
$m - M = 4.5 - 1.31 = 3.19$
which is a factor of $\frac{\lg(3.19)}{\lg(10^{\frac{2}{5}})} = 1.2595$ difference in brightness (B)
Since $B \propto \frac{1}{d^2}$, d = dist. to ★,
Distance ratio $\frac{D_m}{D_M} = \left(\frac{B_M}{B_m}\right)^{\frac{1}{2}} = 1.2595^{\frac{1}{2}} = 1.1223$.
By definition, $D_M = 10pc$.
$D_m = 1.1223 D_M = 1.1223 \times 10 = 11.2$ pc

I did not ask you to calculate the distance, and your distance is wrong. You could have checked your answer...

Short Answer Questions

a) LST = RA$_{\star}$ = 2:30:49 am

Distance can be determined via ~~parallax~~ observed parallax. Or use Google. The second method is the most feasible as almost everybody has access to the Internet.

(b) With
your

ratio D_M (Bmi)

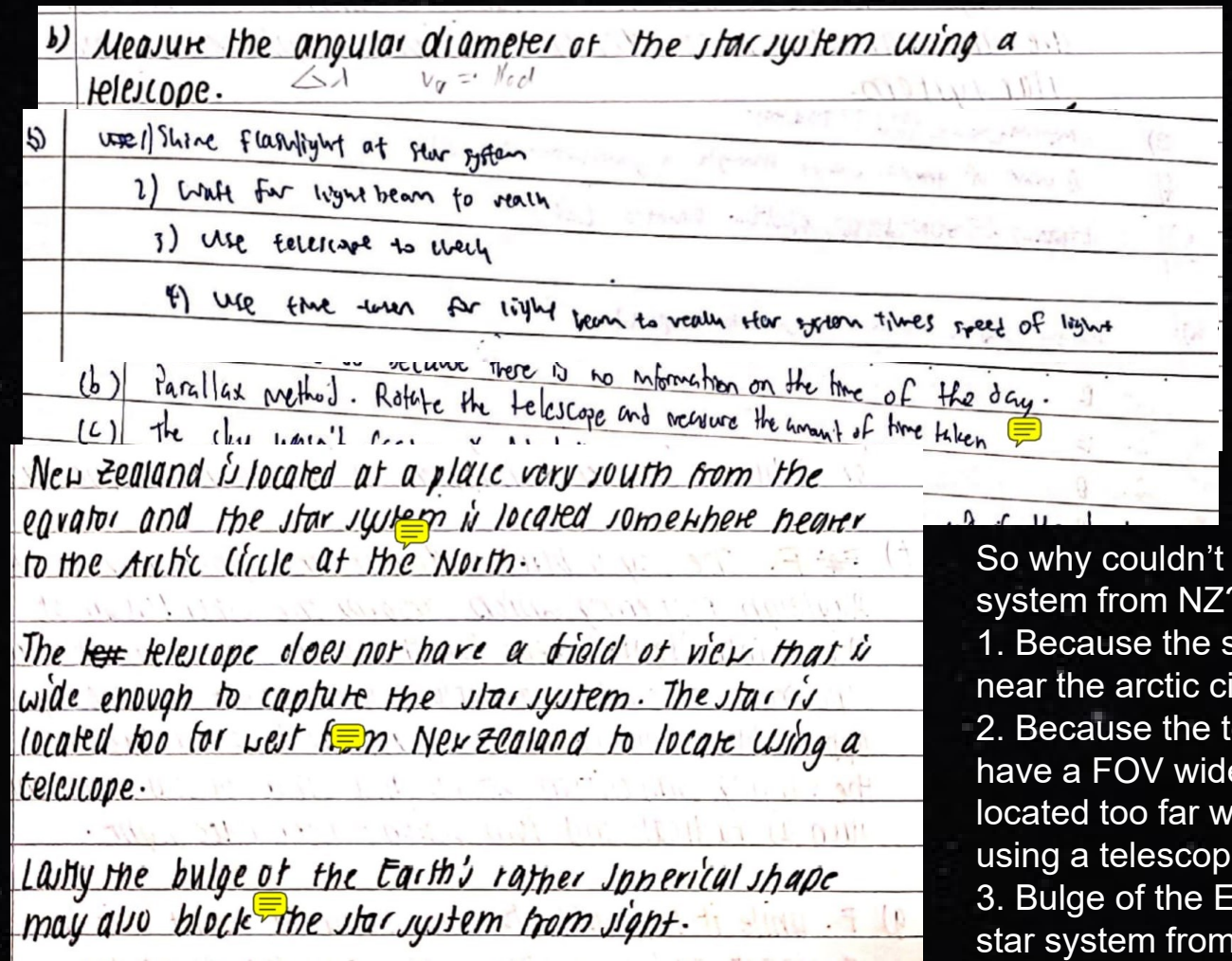
By definition, $D_M = 10pc$.

$D_m = 1.1223\, D_M = 1.1223 \times 10 = 11.2$ pc

Even though this is Tongue in Cheek, it does seem like an answer which addresses the question better...

Short Answer Questions

- Answers which are too embarrassing to share:



b) Measure the angular diameter of the star system using a telescope.

5) ~~use~~ 1) Shine flashlight at star system
2) wait for light beam to reach
3) use telescope to track
4) use time taken for light beam to reach star system times speed of light

(b) Parallax method. Rotate the telescope and measure the amount of time taken

because there is no information on the time of the day.

(c) The sky wasn't [illegible]

New Zealand is located at a place very south from the equator and the star system is located somewhere nearer to the Arctic Circle at the North.

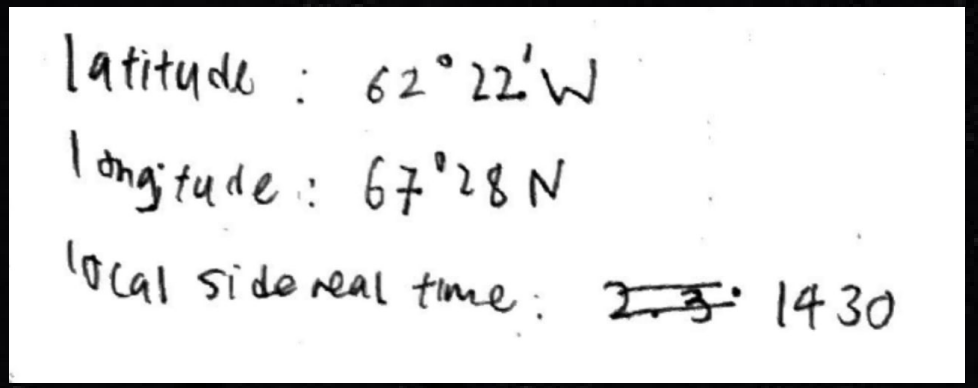
The ~~left~~ telescope does not have a field of view that is wide enough to capture the star system. The star is located too far west from New Zealand to locate using a telescope.

Lastly the bulge of the Earth's rather spherical shape may also block the star system from sight.

How to tell the distance to the star cluster?
1. Measure using telescope
2. Shine flashlight at star system
3. Rotate telescope and measure amount of time taken...

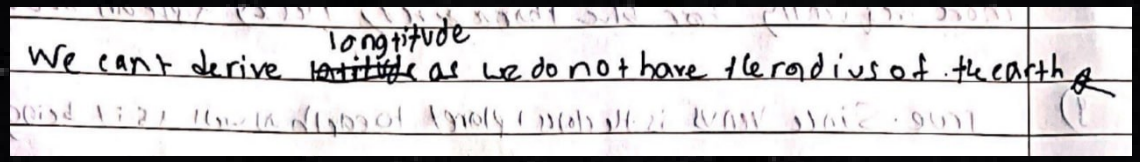
So why couldn't you see the star system from NZ?
1. Because the star system is located near the arctic circle... (BOD ok)
2. Because the telescope does not have a FOV wide enough. The star is located too far west from NZ to locate using a telescope... (What?)
3. Bulge of the Earth.... may block the star system from sight.

Short Answer Questions

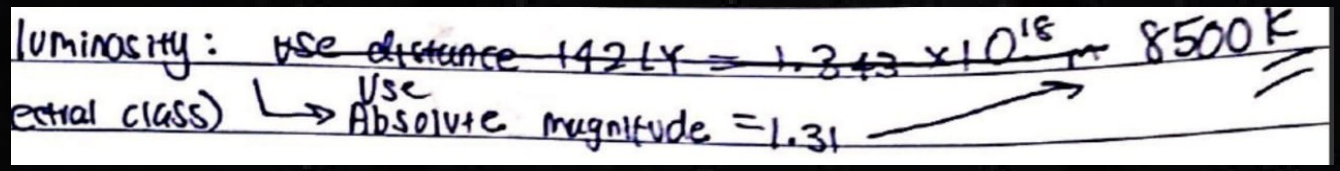

latitude : 62° 22' W
longitude : 67° 28 N
local sideral time : ~~2.3~~ 1430

Mixed up latitude and longitude.

- Lack of basic Knowledge:


We can't derive ~~latitude~~ longtitude as we do not have the radius of the earth

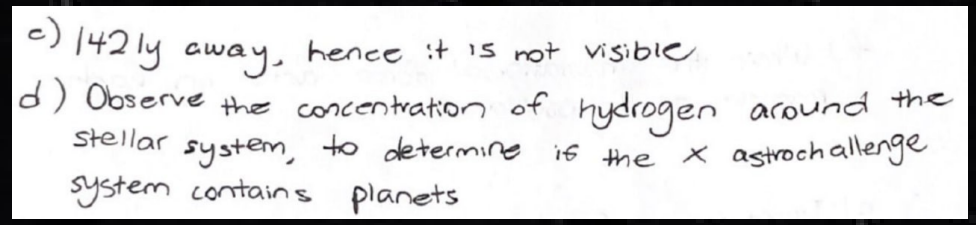
Cannot longtitude because dk radius of the Earth (???)
1. It is provided in the formula book
2. What sorcery are you promoting

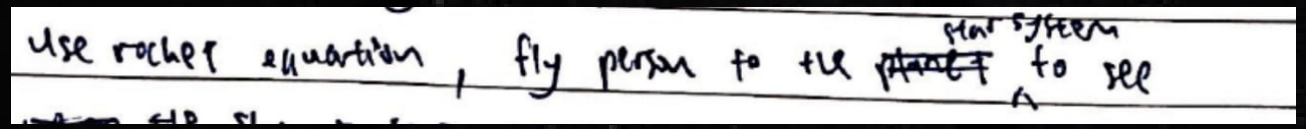

luminosity : ~~use distance 142 LY = 1.343 x 10^18 m~~ 8500 K
ectral class) → Use Absolute magnitude = 1.31

Luminosity: ….(butchers data)… gets answer = 8500K (???)

Short Answer Questions

- More stuff:


c) 142 ly away, hence it is not visible
d) Observe the concentration of hydrogen around the stellar system, to determine is the x astrochallenge system contains planets


use rocket equation, fly person to the ~~planet~~ star system to see

So why couldn't you see the star system from NZ?

Because the star system is 142 LY away.... (What?)

How do you detect exoplanets?

1. Measure Hydrogen...
2. Use rocket equation, fly person to the star system to see...

Question 2: Operation Binary

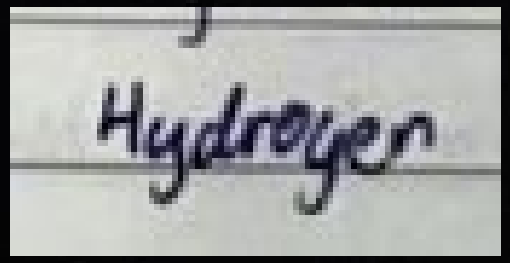
Q Setter: Denny

(a) What are neutron stars mainly composed of?

Rookie Mistakes

Neutron stars are made up of heavy-metals.

They are mainly composed of ordinary atomic nuclei crushed into a solid lattice with a sea of delocalised electrons.



(b) What is the period of the binary system?

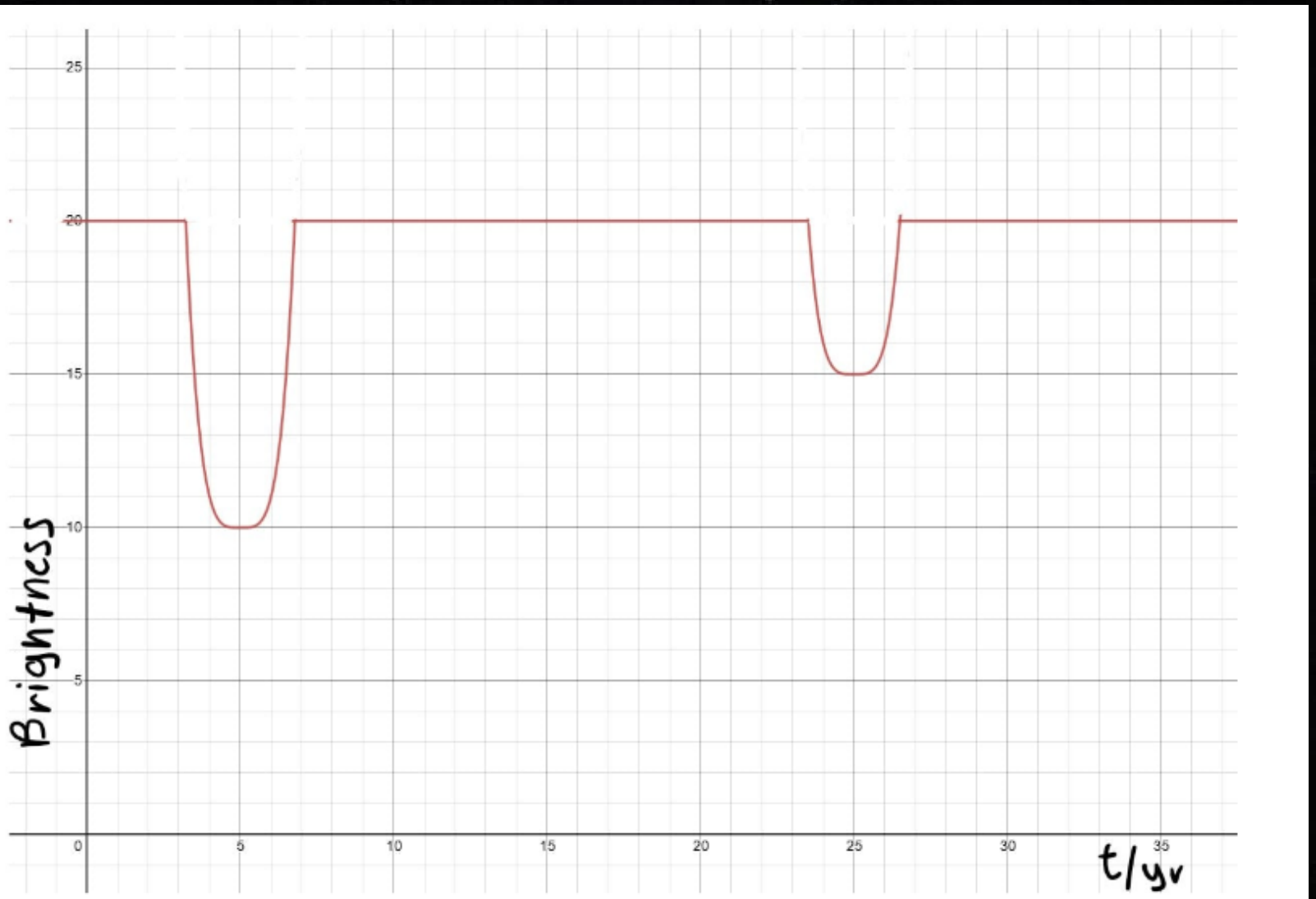
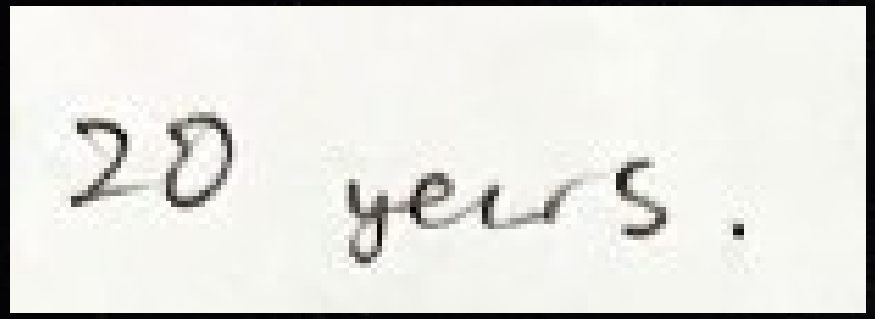
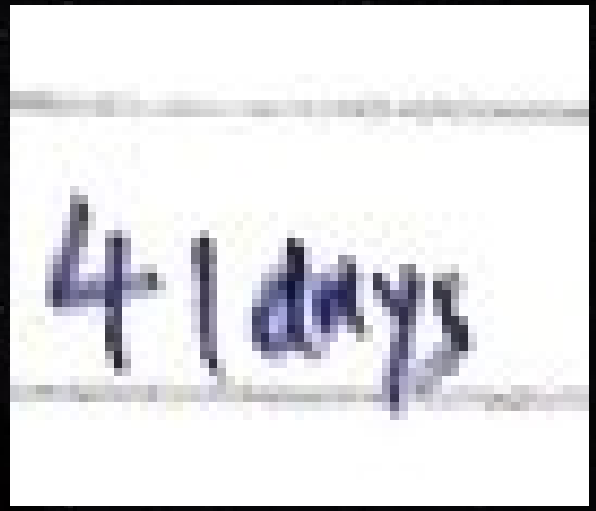


Figure 1: Graph of brightness of the binary star system against time

Rookie Mistakes





(c) Using Newton's law of gravitation and Newton's second law, show that the period, P, of the binary system is $P = \sqrt{\frac{4\pi^2 R^2}{G(m_1+m_2)}}$. Assume both orbits are circular.

Good examples:

c. Since the period of the two stars are the same,

$$P_1 = P_2$$

$$\frac{2\pi r_1}{v_1} = \frac{2\pi r_2}{v_2}$$

$$\frac{v_1}{v_2} = \frac{r_1}{r_2}$$

Since ratio also applies to mass,

$$\frac{r_1}{r_2} = \frac{v_1}{v_2} = \frac{m_2}{m_1}$$

By N2L,

$$F_c = F_g$$

$$\frac{4\pi^2 m_1 r_1}{T^2} = \frac{G m_1 m_2}{(r_1 + r_2)^2}$$

$$\frac{4\pi^2 r_1}{T^2} = \frac{G m_2}{(r_1 + r_2)^2}$$

$$R = r_1 + r_2$$

$$= r_1\left(1 + \frac{r_2}{r_1}\right)$$

$$= r_1\left(1 + \frac{m_1}{m_2}\right)$$

$$= r_1\left(\frac{m_2 + m_1}{m_2}\right)$$

$$= \frac{r_1}{m_2}(m_1 + m_2)$$

$$\frac{m_2}{r_1} = \frac{m_1 + m_2}{R}$$

$$\therefore \frac{4\pi^2 r_1}{P^2} = \frac{G m_2}{R^2}$$

$$\frac{4\pi^2}{P^2} = \frac{m_2}{r_1}\frac{G}{R^2}$$

$$\frac{4\pi^2}{P^2} = \left(\frac{m_1 + m_2}{R}\right)\frac{G}{R^2}$$

$$\frac{4\pi^2}{P^2} = \frac{G(m_1 + m_2)}{R^3} R^2$$

$$\frac{P^2}{4\pi^2} = \frac{P^2}{G(m_1 + m_2)}$$

$$P^2 = \frac{4\pi^2}{G(m_1 + m_2)} R^3$$

$$P = \sqrt{\frac{4\pi^2 R^3}{G(m_1 + m_2)}} \quad \text{(shown)}$$

(d) Using Part c, show that the sum of the masses of the binary stars is

$$m_1 + m_2 = \left(\frac{P}{2\pi G}\right)(v_1 + v_2)^3.$$

Good examples:

$$V_1 = \left(\frac{R m_2}{m_1+m_2} \frac{1}{T} 2\pi\right)$$

$$V_2 = \left(\frac{R m_1}{(m_1+m_2)} \frac{1}{T} 2\pi\right)$$

$$V_1 + V_2 = 2\frac{R}{T}\frac{1}{(m_1+m_2)}(m_1+m_2)\pi$$

$$V_1+V_2 = 2\frac{R}{T}\pi$$

$$(V_1+V_2)^3 = 8\left(\frac{R}{T}\right)^3\pi^3$$

$$\frac{R^3}{T^2} = (V_1+V_2)^3 \; T \; \frac{1}{8} \; \frac{1}{\pi^3}$$

$$T^2 = \frac{4\pi^2 R^3}{G(m_1+m_2)}$$

$$m_1+m_2 = \frac{4\pi^2}{G}\frac{R^3}{T^2}$$

$$m_1+m_2 = \frac{4\pi^2}{G}(V_1+V_2)^3 \; T \; \frac{1}{8} \; \frac{1}{\pi^3}$$

$$= \frac{T}{2G\pi}(V_1+V_2)^3$$

shown

(c) The radial velocity of the two stars have been determined to be $v_{1r} = 20\text{kms}^{-1}$ and $v_{2r} = 40\text{kms}^{-1}$. Determine the masses of the binary stars.

2e. $\frac{v_1}{r_1} = \frac{v_2}{r_2}$

$v_1 r_2 = v_2 r_1$

$v_1 \left(\frac{m_2 R}{m_1 + m_2}\right) = \left(\frac{m_1 R}{m_1 + m_2}\right) v_2$

$\frac{v_1}{v_2} = \frac{m_1}{m_2}$

$\frac{m_1}{m_2} = \frac{1}{2}$

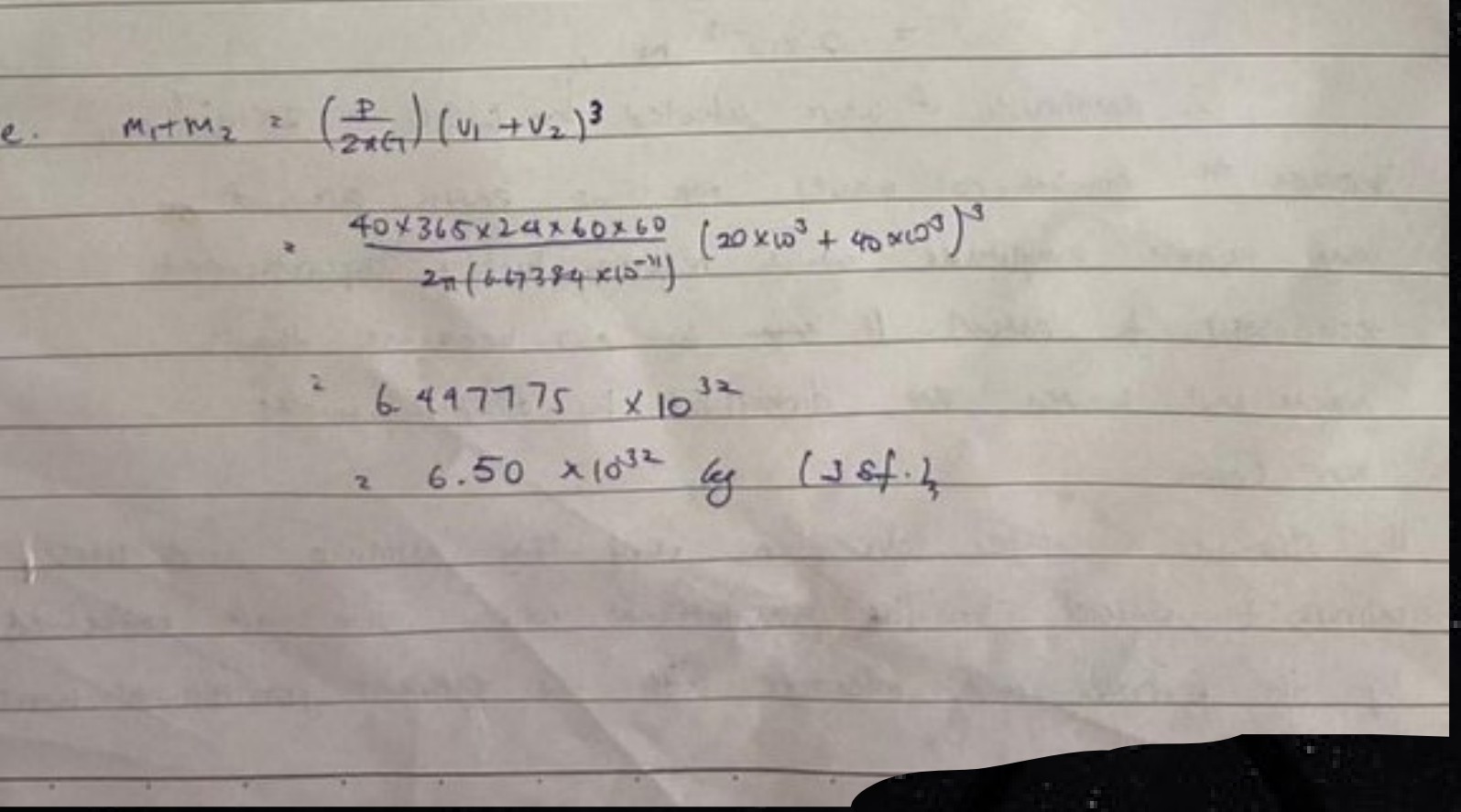
$m_1 = (m_1 + m_2)\left(\frac{1}{3}\right) = 2.167 \times 10^{32} kg$

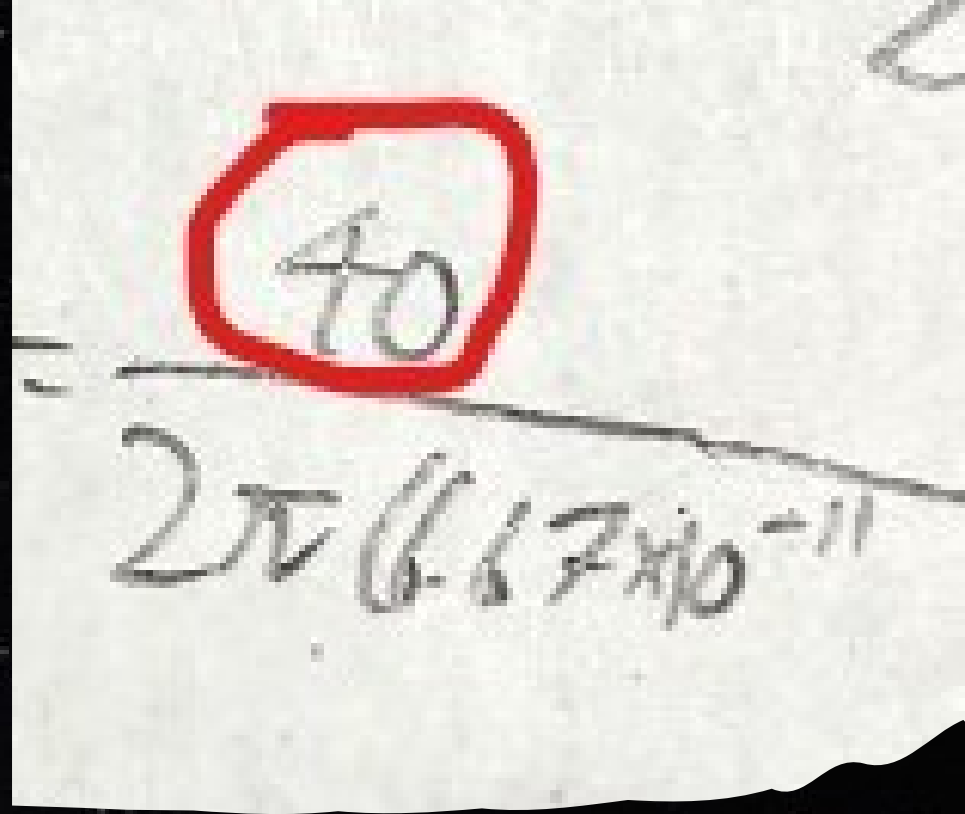
$m_2 = (m_1 + m_2)\left(\frac{2}{3}\right) = 4.33 \times 10^{32} kg$

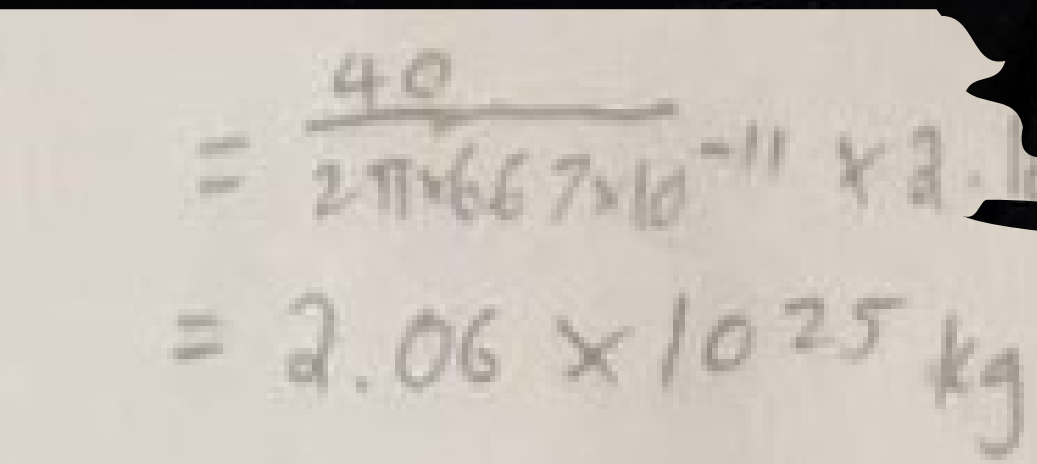
$m_1 + m_2 = \frac{P}{2\pi G}(v_1 + v_2)^3$

$m_1 + m_2 = \frac{40 \times 365 \times 24 \times 60 \times 60}{2\pi G}(80000)^3$

$= 6.5015 \times 10^{32} kg$



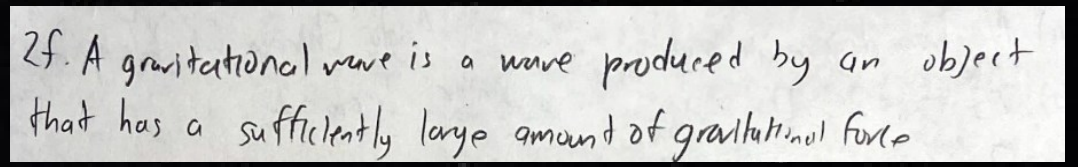


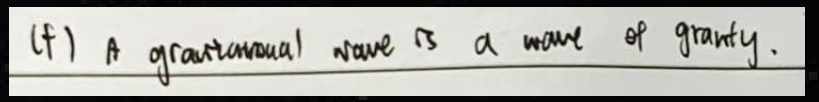


Rookie Mistakes

(f) In your own words, describe what a gravitational wave is.

Rookie Mistakes





A gravitational wave is a wave which distorts the spacetime around it. A mass will generate a gravitational wave as it accelerates through spacetime, causing ripples called gravitational waves.

Wikipedia

Gravitational waves are disturbances in the curvature of spacetime, generated by accelerated masses, that propagate as waves outward from their source at the speed of light.

NASA

What Is a Gravitational Wave?

The Short Answer:

A gravitational wave is an invisible (yet incredibly fast) ripple in space. Gravitational waves travel at the speed of light (186,000 miles per second). These waves squeeze and stretch anything in their path as they pass by.

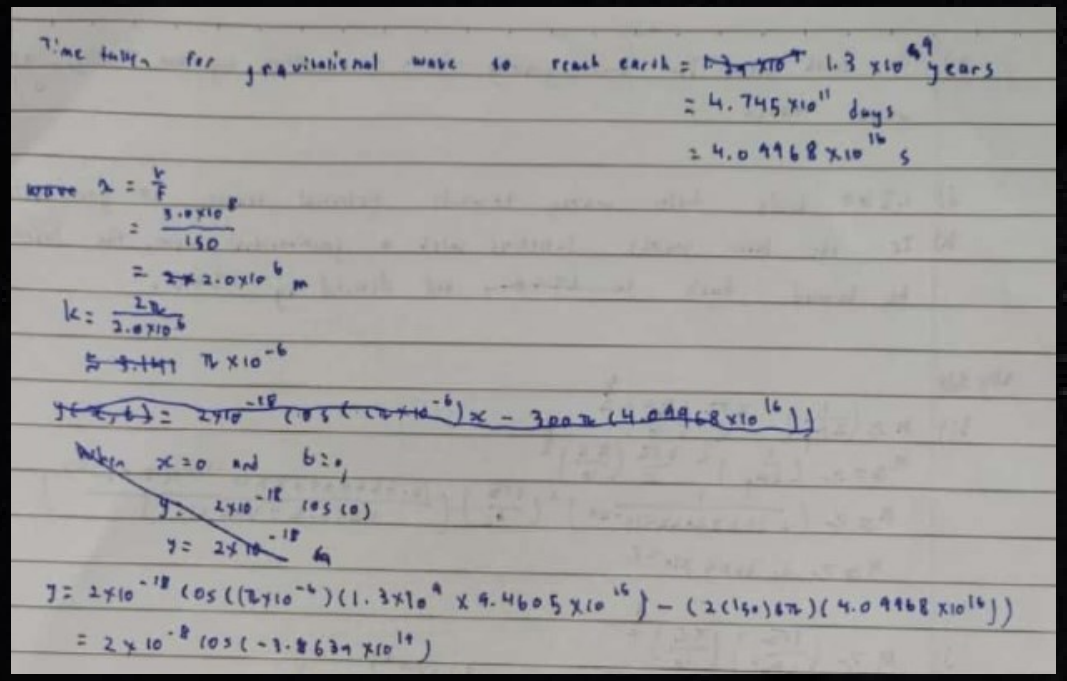
His name?

Albert Einstein

violent and energetic processes in the Universe. Albert Einstein predicted the existence of gravitational waves in 1916 in his general theory of relativity. Einstein's mathematics showed that massive accelerating objects (such as neutron stars or black holes orbiting each other) would disrupt space-time in such a way that 'waves' of undulating space-time would propagate in all directions away from the source. These cosmic ripples would travel at the speed of light, carrying with them information about their origins, as well as clues to the nature of gravity itself.

(g) Take $t = 0$s as the time the gravitational wave was generated and $x = 0$ as the source of the gravitational wave. The gravitational waves are determined to have frequency 150Hz and peak amplitude $A = 2 \times 10^{-18}$m. Determine the amplitude of the wave when it is detected by LIGO. Take a year to be 365 days.

Rookie Mistakes



$$y(x,t) = A\cos(kx - \omega t)$$
$$= 2\times10^{-18}\cos\left(\frac{2\pi fx}{v} - (2\pi f)t\right)$$
$$= 2\times10^{-18}\cos\left[\frac{2\pi(150)}{3\times10^8}(1.3\times10^9\times9.4605\times10^{15}) - 2\pi(150)(1.3\times10^9\times365\times24\times60\times60)\right]$$

$$y(x,t) = A\cos(kx - \omega t)$$

$$A = 2\times10^{-18}$$

$$\omega = 2\pi f$$

$$k = \frac{2\pi}{\lambda} = \frac{2\pi}{\left(\frac{c}{f}\right)} = \frac{2\pi f}{c}$$

$$y = 2\times10^{-18}\cos\left(\frac{2\pi f}{c}ct - 2\pi f t\right)$$

$$= 2\times10^{-18}\cos 0 = 2\times10^{-18}\,m$$

Good examples:

2g) $c = 3\times10^8$ m/s $d = 1.3\times10^9$ Ly. $t = 1.3\times10^9 \times 365\times24\times60\times60 = 4.10\times10^{16}$ s

$x = 3\times10^8 \times 1.3\times10^9 \times 365 \times 24\times60\times60$

$= 1.23\times10^{25}$ m

$\lambda = \frac{v}{f} = \frac{3\times10^8}{150} = 2\times10^6$

$y(x,t) = 2\times10^{-18}\cos(k(1.23\times10^{25}) - (2\pi(150))(4.10\times10^{16}))$

$= 2\times10^{-18}\cos\left(\frac{2\pi}{2\times10^6}(1.23\times10^{25}) - 2\pi(150)(4.1\times10^{16})\right) = 2\times10^{-18}$ m //.

Good examples:

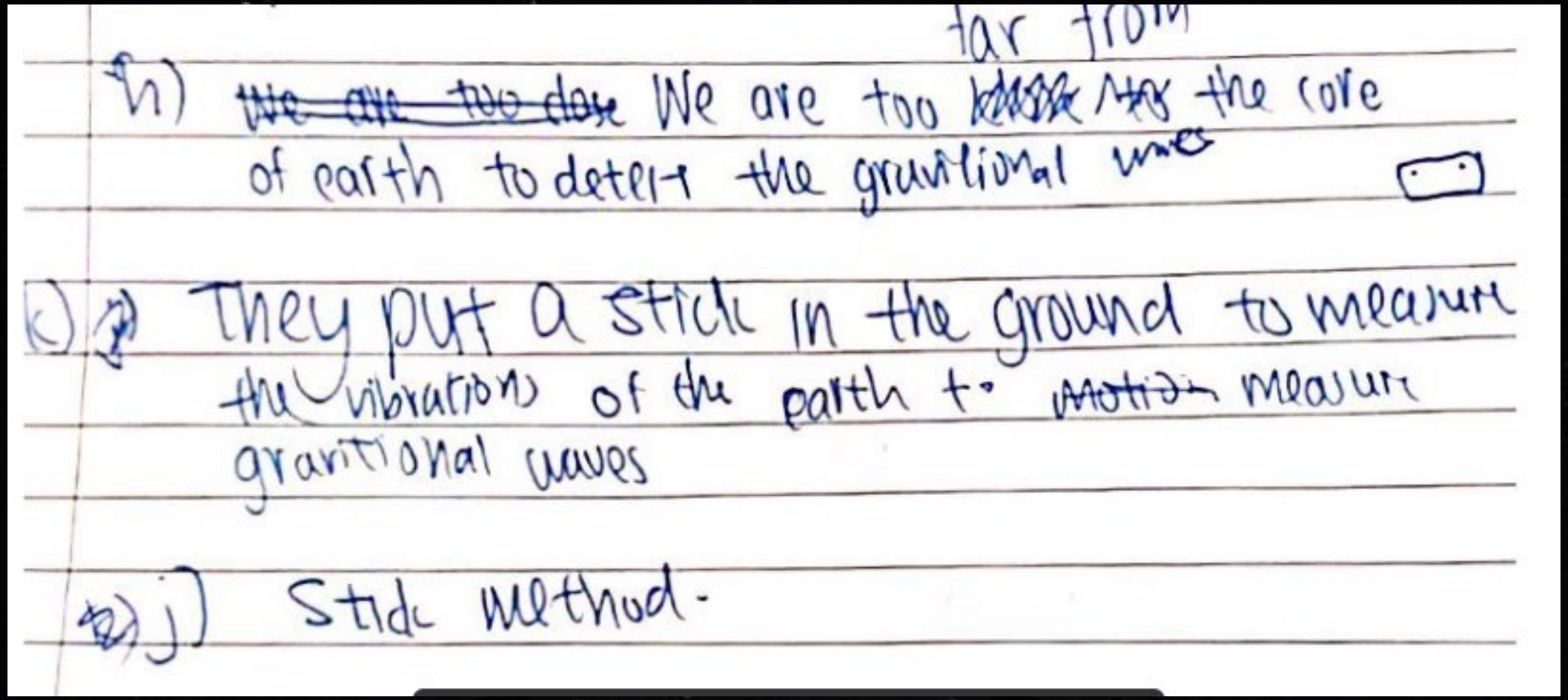
(h) Why are gravitational waves difficult to detect on Earth?

This futuristic version of LIGO is faithful to the original systems used in LIGO of the early 21^{th} century.

(j) State the method LIGO uses to detect gravitational waves.

(k) Explain how the method used in Part j allows LIGO to detect gravitational waves.

Rookie Mistakes



Good examples:

(k) A laser is split into 2 beams that traverse perpendicular paths, before being reflected back to the same point. Gravitational waves will cause the length of one path to differ from the other, so that the beams travel different distances and are hence out of phase when they arrive at the detector. This allows gravitational waves to be detected as the 2 beams would be coherent (in phase) when no gravitational waves are passing through LIGO.

k) ~~They run 2 lines~~ There are 2 lazers that run parallel to each other, ~~and~~ and ~~they are~~ since gravitational waves bend space, they can cause the space between the lazers to increase or decrease which would then cause the time taken for the ~~lasers~~ lazer lights to travel to be different. When the time taken for ~~the~~ the ~~light~~ light of lazers to travel is longer or shorter, ~~there~~ there is a gravitational wave.

Good examples:

Question 2

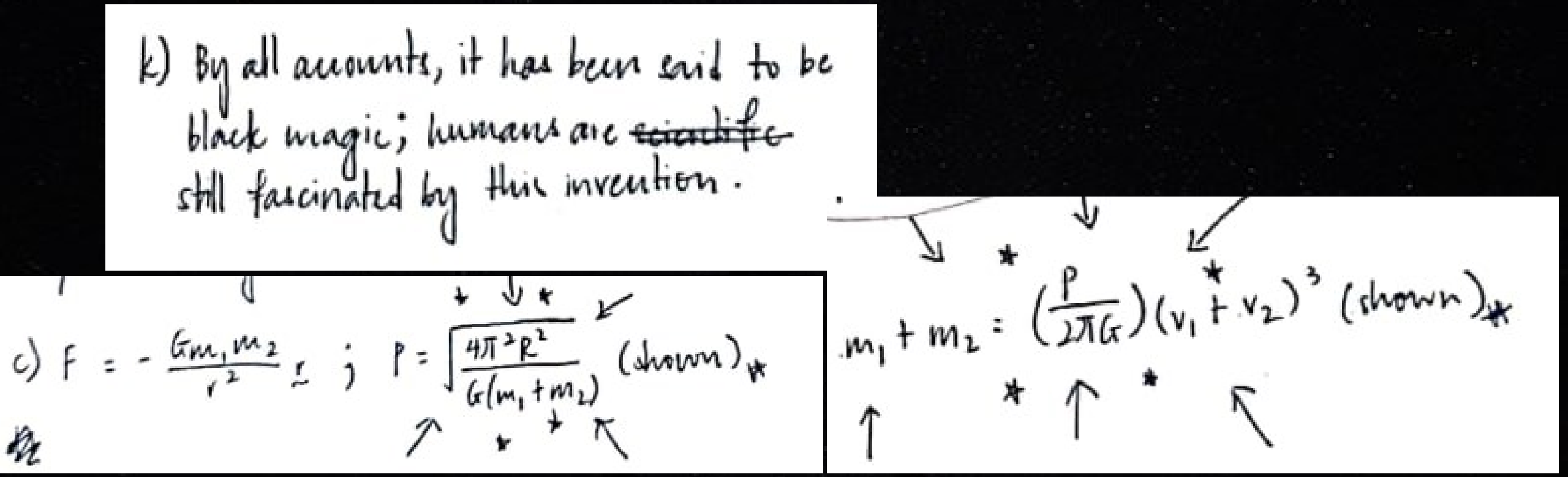
Moodgnie is ... the ... level in the Hub trilogy.

(j) LIGO was laser interferometry, where they shoot beams of particles at relativistic speeds back and forth through very long tubes.

(h) Since gravitational waves are in effect, ripples through spacetime, when a gravitational wave passes through the Earth, it causes the time taken for particles to travel through the tube to vary somewhat. By measuring that, we can infer whether gravitational waves have passed through.

Good examples:

Black Magic:



When I asked you to show… I did not mean to draw arrows leading to it…

Question 3: All about limits

Q Setter: Ryan

Comments

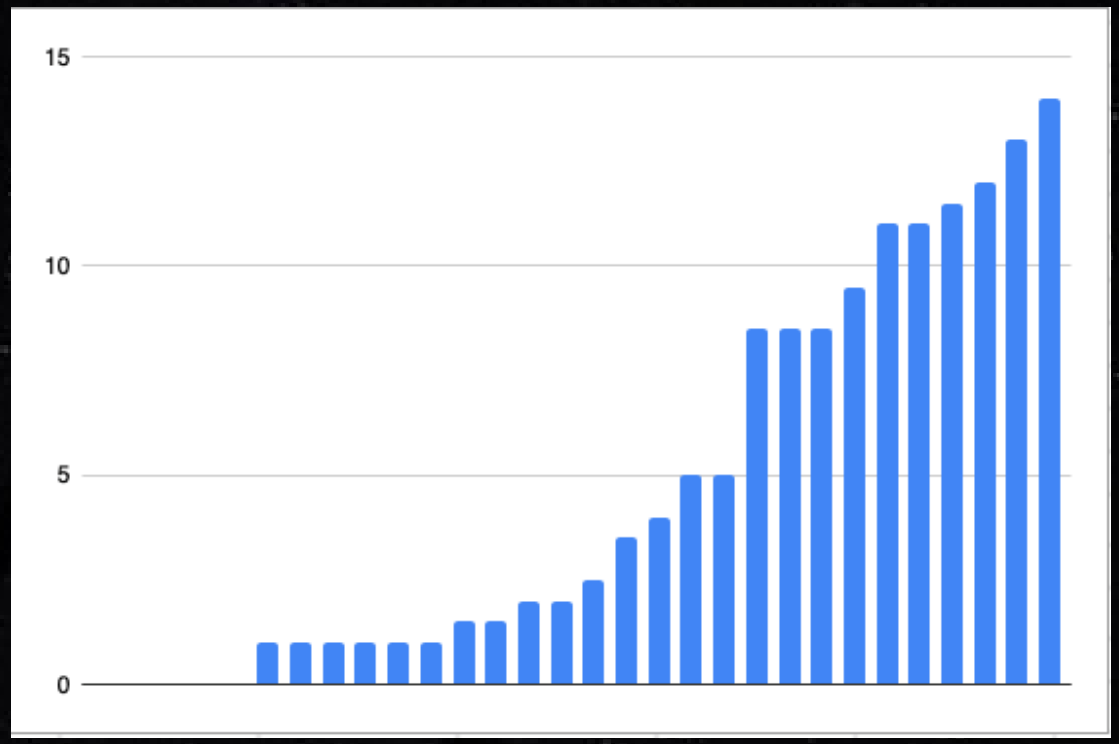
- Teams who read the whole question managed to get the free marks
- Idea:
  - Think about why Chandrasekar Limit exists
  - Why are white dwarfs so stable?

The Statistics

Mean: 4.68

Median: 2.25

Standard Deviation: 4.68



Part I: Fermi Gas

read the *PREAMBLE*

Let us first examine a **Fermi gas** in more detail. A Fermi gas is simply a gas of non-interacting fermions. Fermions are particles that include protons, neutrons, and electrons.

non-interacting : no electron-electron repulsion

Part I: Fermi Gas

and is unable to be pushed down to a lower
(b) As electrons occupy a ~~higher~~ higher energy level, repulsion
between electron clouds are more significant, causing atoms to repel

repulsion of electrons

repulsion between the electron clouds

repulsion of electrons

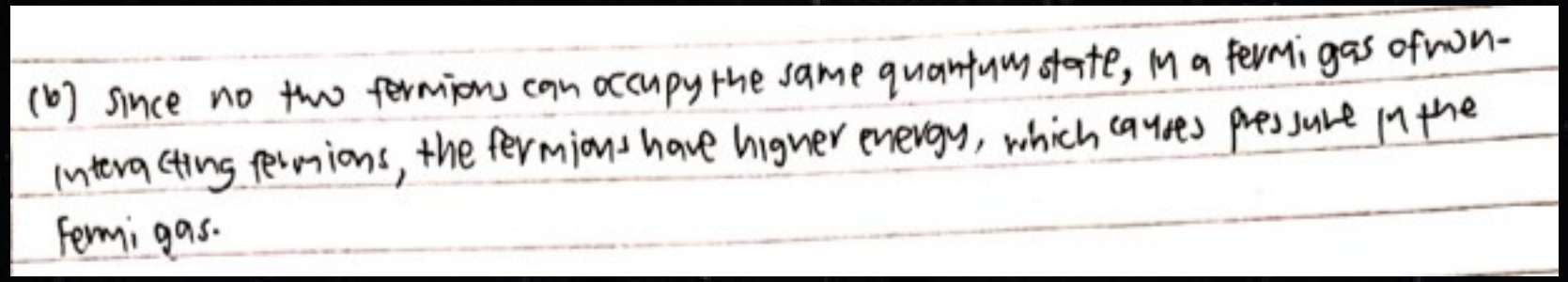
$e^- - e^-$ repulsion

Coloumb repulsion force

repulsion between the electrons,

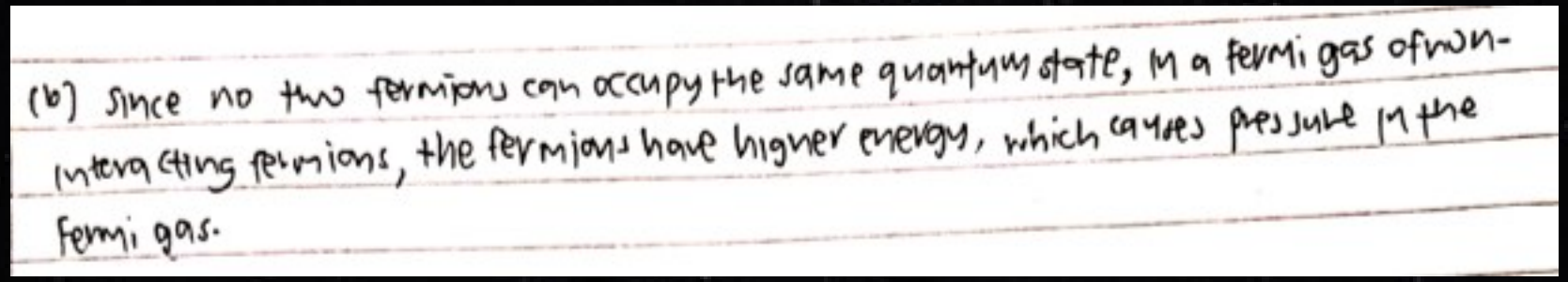
Part I: Fermi Gas

Repeating the question will not net any marks!!



Part I: Fermi Gas

Repeating the question will not net any marks!!



Part I: Fermi Gas

Some teams:

Δp is high => $F = \frac{\Delta p}{\Delta t}$

The "Δp"s are different here! One refers to the uncertainty!

Part II: White Dwarfs

Magical Proof

Part II: White Dwarfs

Most teams were able to get the correct value using

$$E = \frac{p^2}{2m}$$

but did not justify why the total energy is the kinetic energy

=> potential energy = 0 (***non-interacting***)

Part II: White Dwarfs

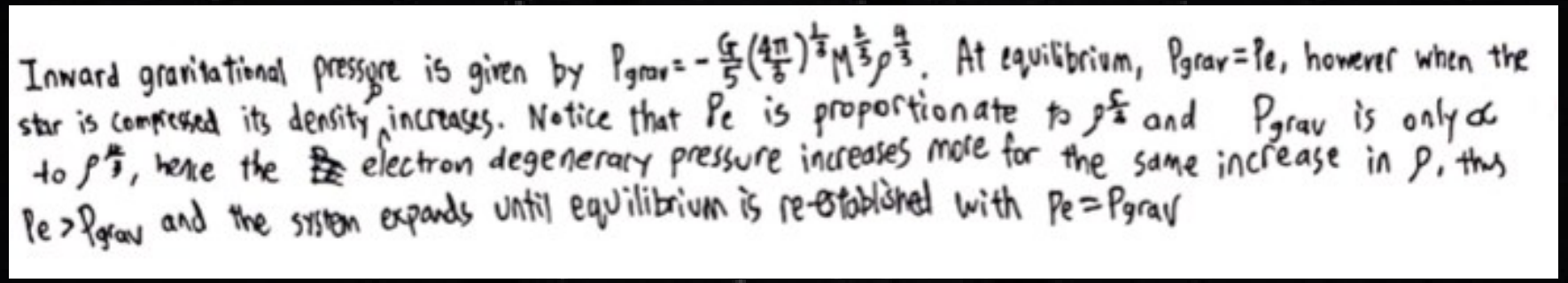
Don’t try to smoke!

There is no ***Compton scattering*** here!!

Part II: White Dwarfs

Most teams who attempted were able to explain the reason behind the stability of a white dwarf, although some did not explain to sufficient detail.

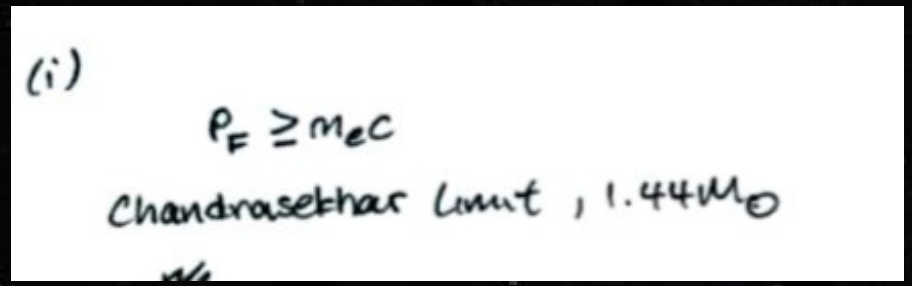
Exemplary answer:



Part II: White Dwarfs

Free marks, as long as you bothered to substitute in the correct numbers!

Our approximation for the number density gives us an expression that is slightly off the actual value of 1.44 Solar Masses…



Please do the calculations!

Part III: Neutron Stars

Again, please read the ***PREAMBLE***!

> Neutrons have a much shorter de Broglie wavelength than electrons at a given energy, which results in them being spaced much more closely than electrons in a Fermi gas. This means that the pressures within neutron stars are much higher than those of white dwarfs.

This paragraph is given for a reason!!

Senior DRQ Question 4

A Certain Academic City

Unluckiest Student
Matou

Academic City

Nooo! My breakfast…!
Eh? There was homework??
Oh no!! I forgot about the test!
Waagh! Who put a banana peel there!?

How unlucky…!!

Academic City Observatory

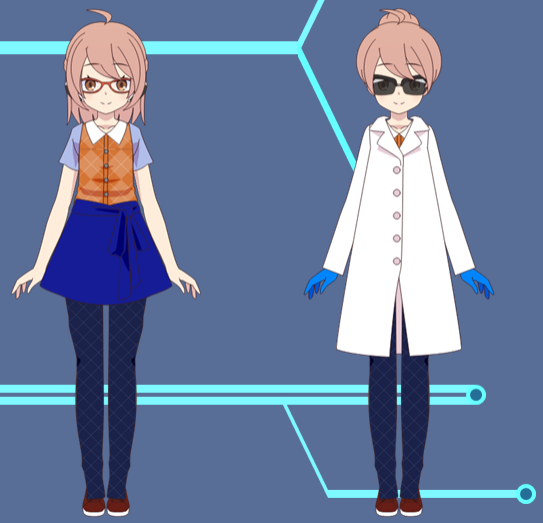
Denpa Ojou
Kotomi

Academic City

Don't call me 'denpa'!!!

Huh? It suits me?
Don't give me that!
Sure, I love electromagnetism.
But I'm just a researcher, okay!?

I'm not a weird girl, okay!?



Level Five
Cosmic Ray Energy Lab

Smartest One
Akuta

Academic City

A magnitude.
A direction.
The problem doesn't matter.
As long as it has a vector.

I will solve it.

Level Five
Cosmic Ray Energy Lab

SNR DRQ 4: A Certain Academic City

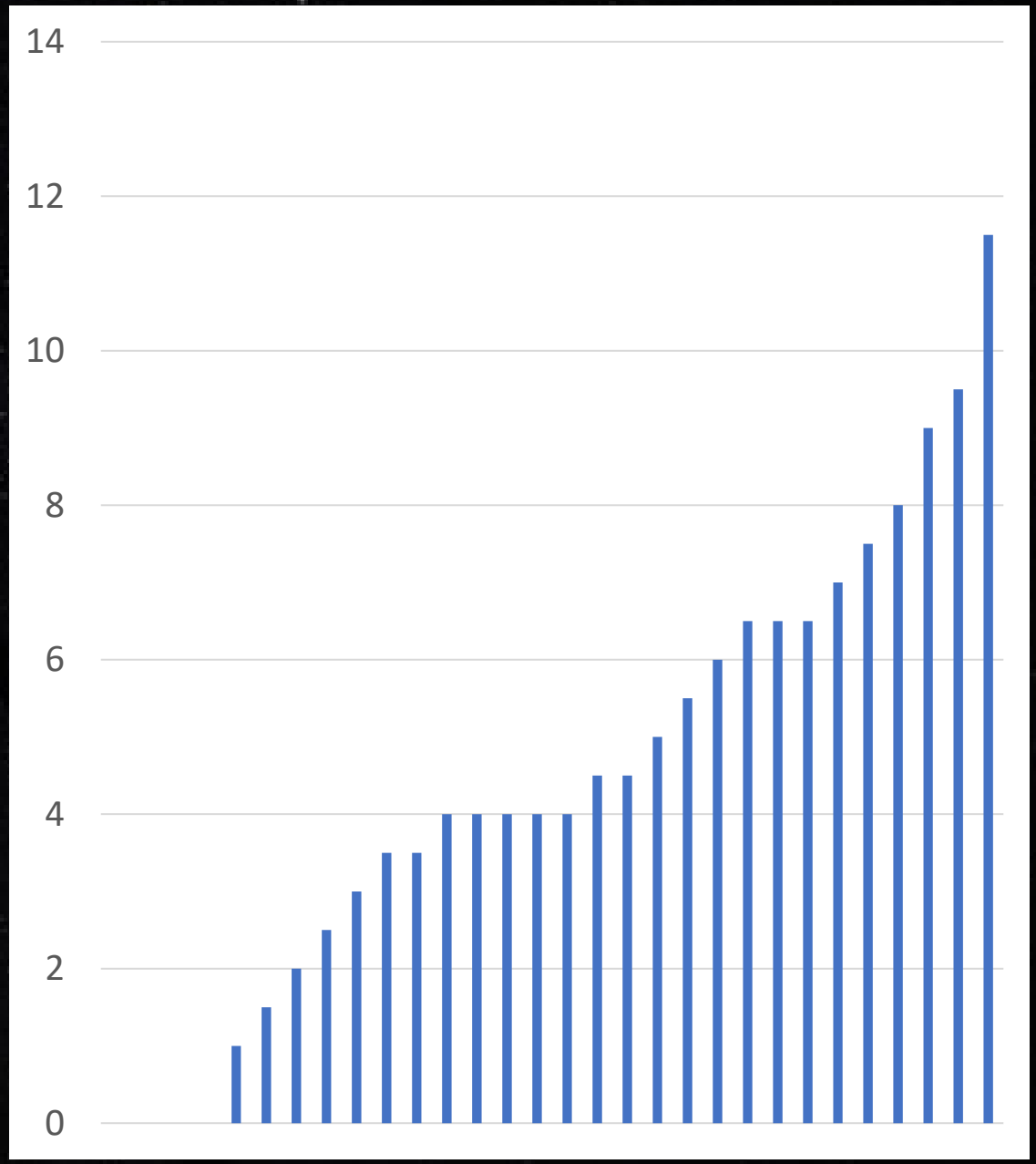
- Idea behind the question:
  - A two-shot question based around electricity and magnetism.
    - Colour index
    - Magnetic reconnection
- Parts (generally) increase in difficulty as the tour progresses.

- Fun facts:
  - Based around the titles of *Toaru Majutsu no Index* and related.
  - Question began as a pure magnetic reconnection question, and it reminded this setter of the series
  - Shown in background: Academy City (from the series)

SNR DRQ 4 Statistics

- The three measurements
  - Mean: 4.48333
  - Median: 4
  - Mode: 4

- Two more measurements
  - Max: 11.5
  - Min: 0 (because of non-submission)
  - Min: 1 (of those submitted)



Part I: A Certain Colourful Index

- Title references the content:
  - Colour indexes!
- Generally done alright!
- What you did right:
  - Graphs. You guys love graphs. Mostly.
    (Free marks, am I right?)

- What you did wrong:
  - Did not link anomalies/Table data to a (possible) factor affecting B-V beyond “a certain point”

Colour Index Doesn't Change with Distance

- Colour index is a difference of apparent magnitudes.
  - Question: Why doesn't it change with distance?

good question matou.

- Sneaky, sneaky:
  - Disguised question about $m - M = 5 \log \frac{d}{10\ \mathrm{pc}}$. Or mag-brightness.
  - Direct proof:
    - $m_B - m_V = \cdots = M_B - M_V$

Colour Index Doesn't Change with Distance

(a) Let m be the apparant magnitude and M be the absolute magnitude.

$$\begin{cases} m_B - M_B = 5\log_{10}\frac{d}{10pc} \\ m_V - M_V = 5\log_{10}\frac{d}{10pc}. \end{cases}$$

$$\Rightarrow \begin{cases} m_B = M_B + 5\log_{10}\frac{d}{10pc} \\ m_V = M_V + 5\log_{10}\frac{d}{10pc} \end{cases}$$

$$m_B - m_V = M_B + 5\log_{10}\frac{d}{10pc} - \left(M_V + 5\log_{10}\frac{d}{10pc}\right)$$
$$= M_B - M_V.$$

Hence, the difference in absolute magnitude equals to the difference in apparant magnitude.

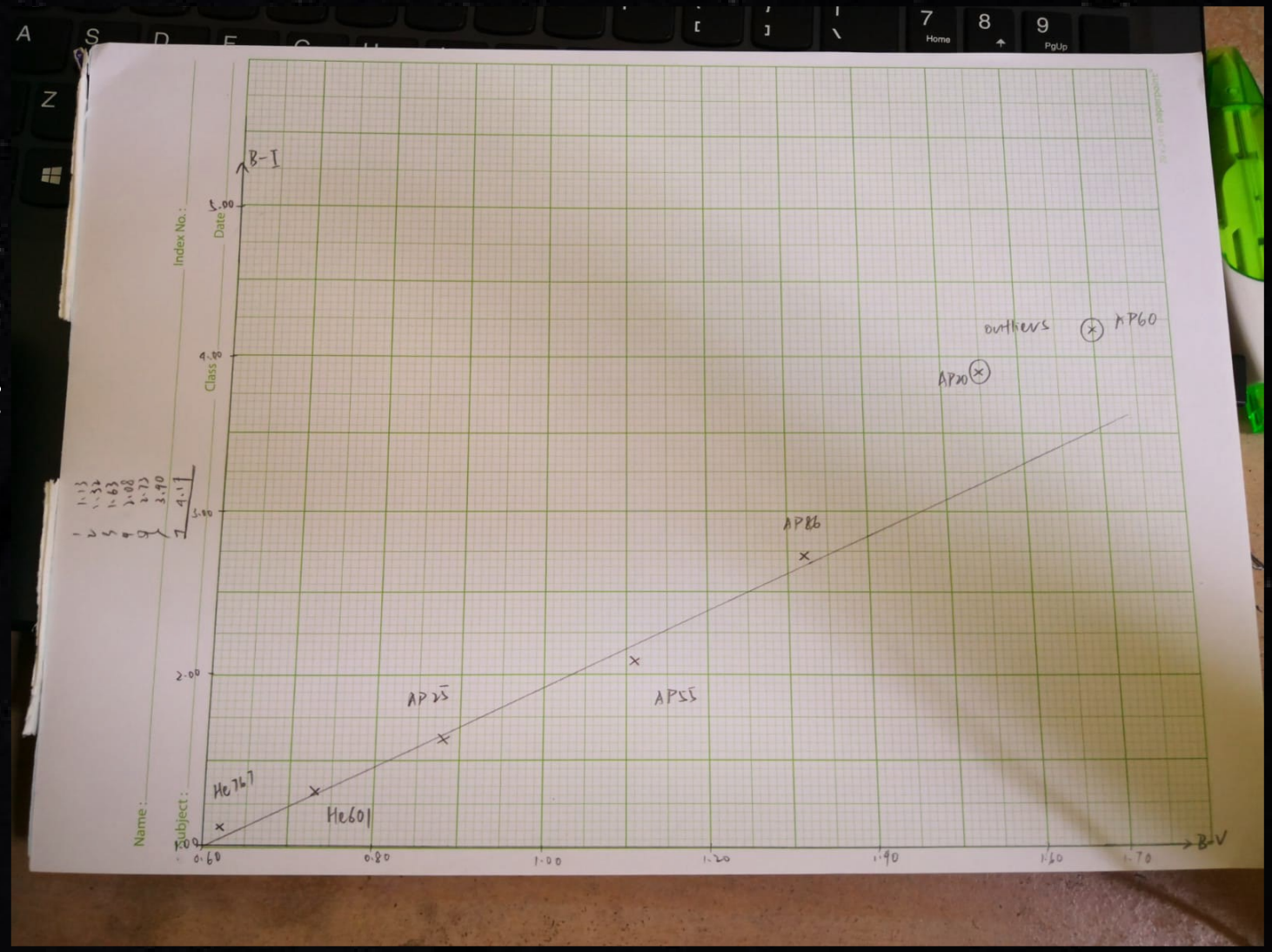
~~For~~ this is also true for other colour indices.

Therefore, the colour index is independent of distance.

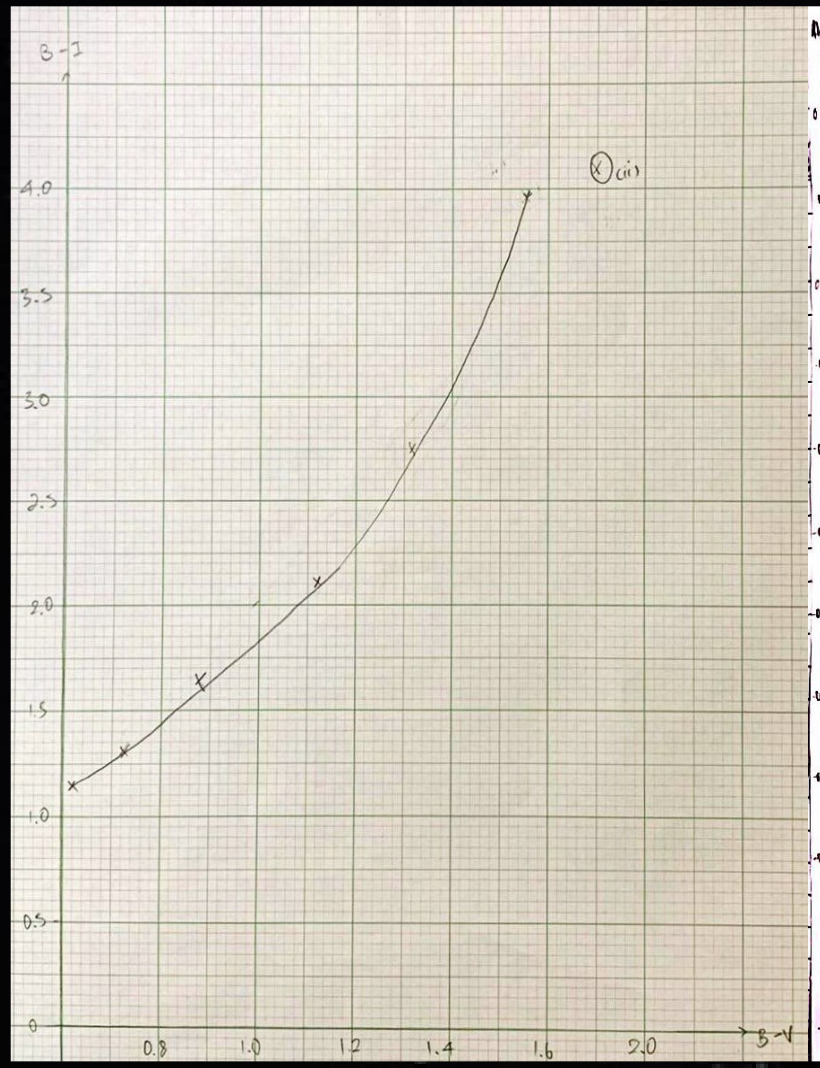
B–I vs B–V: The Free Marks

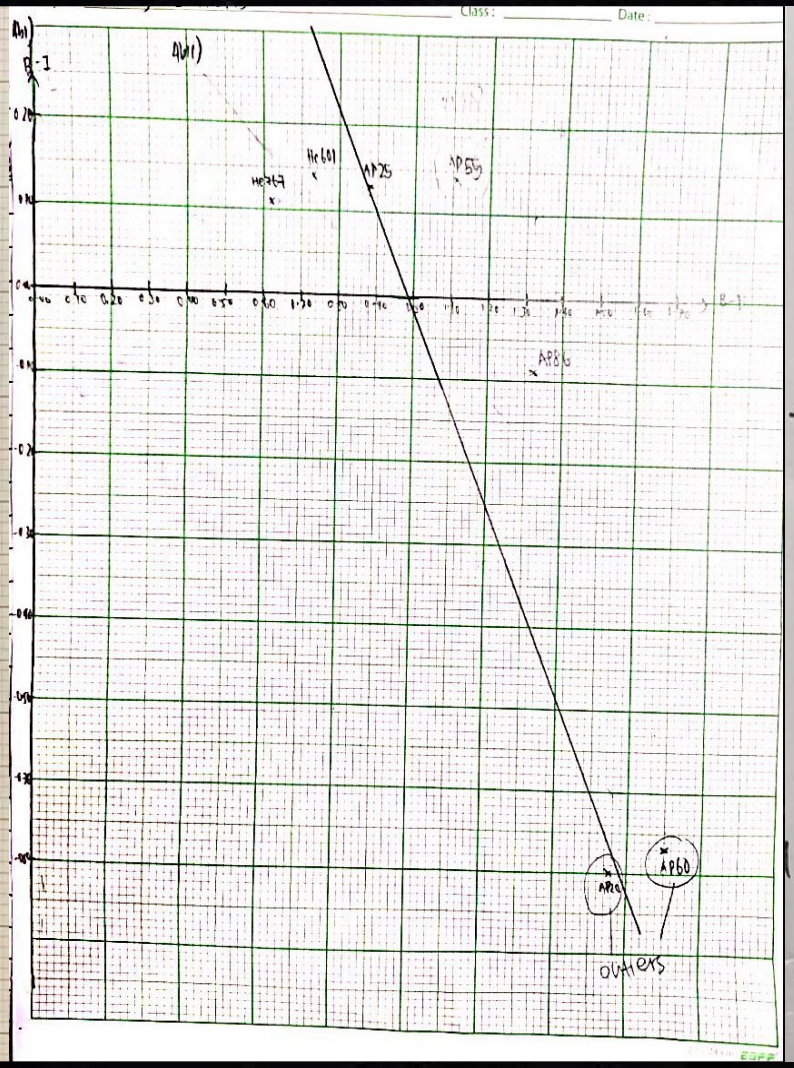
- B–I = B–V + V–R + R–I.
  - Most got this and did fine.

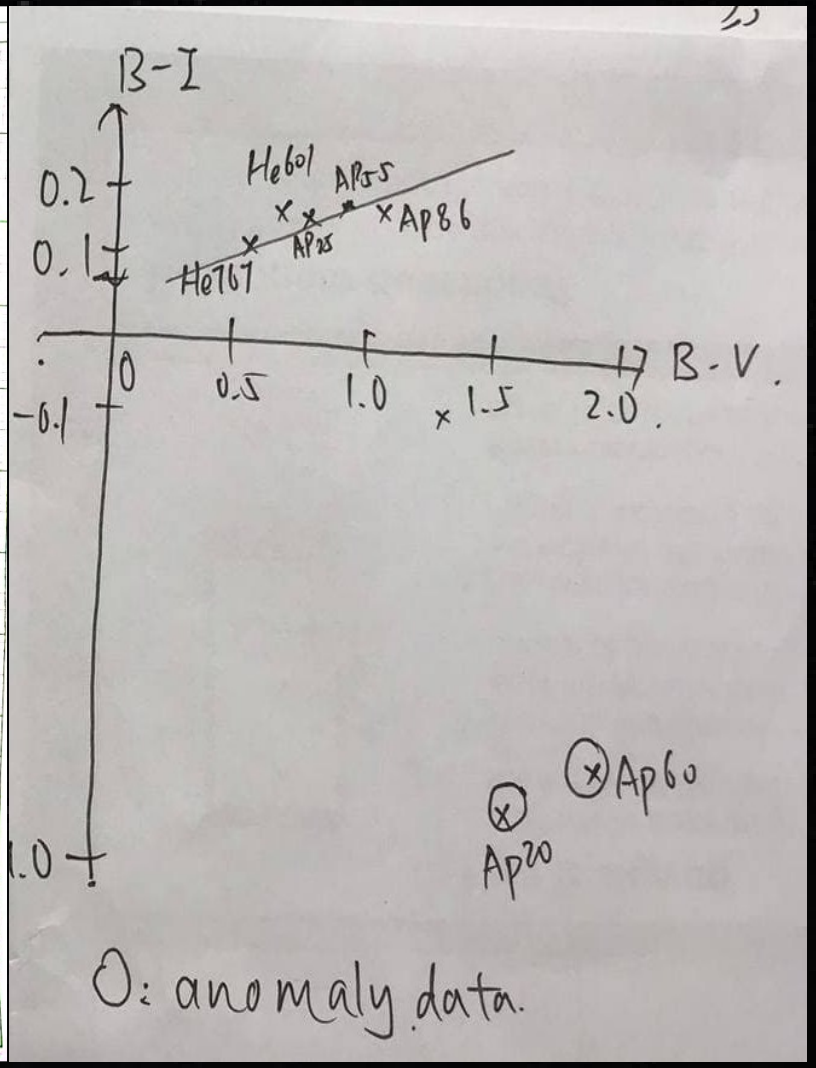
- How It Should Have Ended:
  - Graph on graph paper.
  - First five stars are in linear formation.
  - Draw best-fit line for these five stars!
  - Last two stars are outliers.



B–I vs B–V: How It Should NOT Have Ended



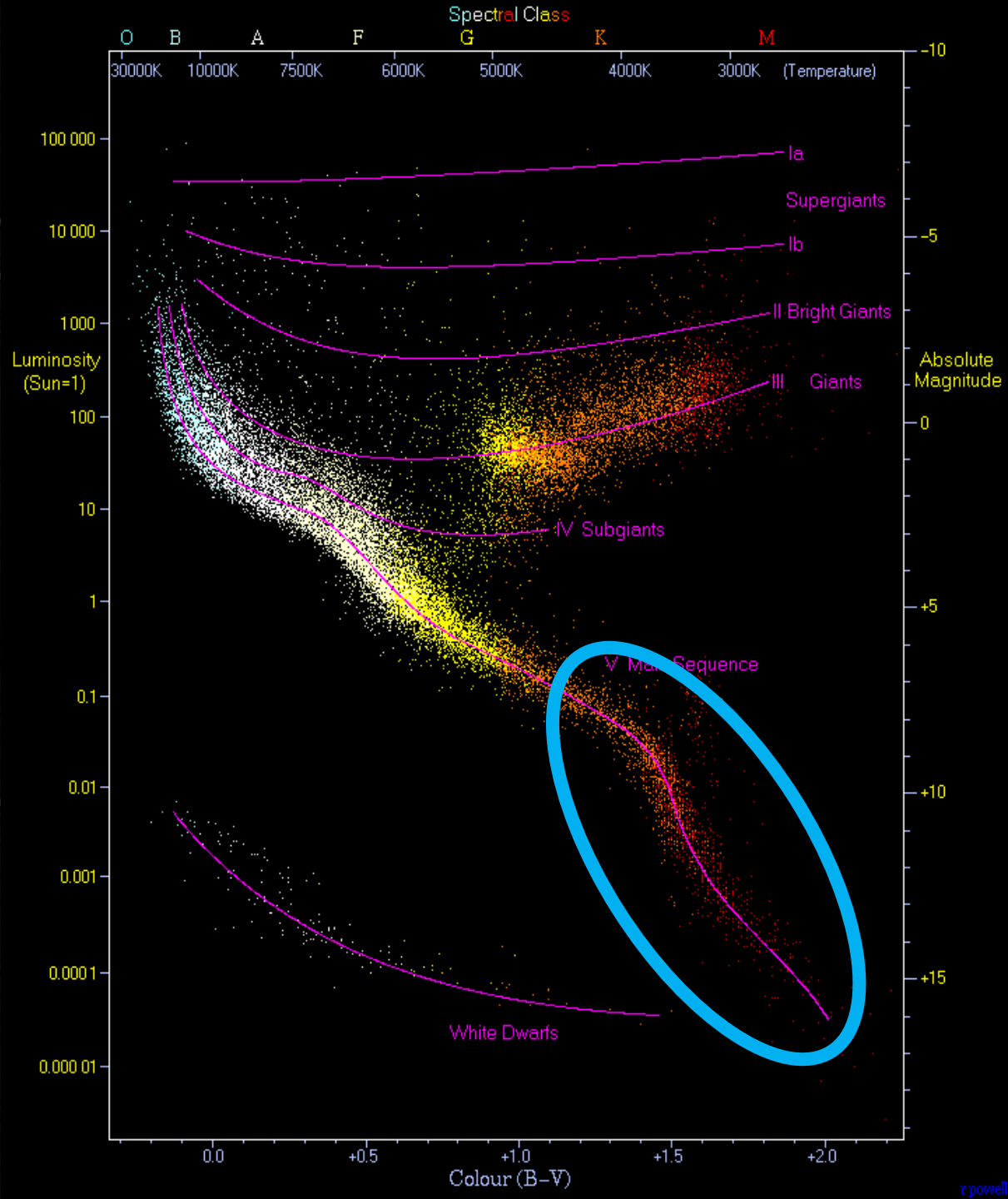




B–I vs B–V: Be Sensitive!

- Two stars with HIGHEST magnitudes deviate from linearity!
  - Hypothesise from this observation!
  - Explanation should NOT apply to *every star in the universe.*

- Onion-cutting Ninja:
  - This is exactly the HR diagram's bottom-right main sequence deviation.



B–I vs B–V: Be Sensitive!

- Spot the mistake
  - Psst: Your stars are gonna be brighter, not dimmer!

Star	V apparent magnitude
He 767	10.69
He 601	11.43
AP 25	12.25
AP 55	13.91
AP 86	14.31
AP 20	15.66
AP 60	15.82

(c) Based on the graph, the 2 outliers who do not follow the linear trend are AP20 and AP60. These stars have a B-I value of above 3.6. These 2 stars are bigger compared to the other stars and have a higher temperature than the rest. This results in their peak emission wavelength to be nearer to the blue spectrum, resulting in them deviating from the linear trend.

Part II: A Certain Scientific Rail/Gun

- Title foreshadows the questions:
  - Particles travel along magnetic field lines (“Rail”).
  - Particles accelerated by magnetic reconnection regions (“Gun”).
- A setup to Part III.
- What you did right:
  - Appreciating the role of E/B fields.
- What you did wrong:
  - Partial answers.
  - Misreading the question!

COLLISIONLESS Energy Transfer

- Appreciate the role of E/B fields in energy transfer
  - It is enough to explain that moving charged particles generate E/B fields.
  - …and those fields affect moving charged particles.
  - Surprisingly, few answered this well…
- Quantum explanation:
  - Highly complicated, look it up if you want.

COLLISIONLESS Energy Transfer

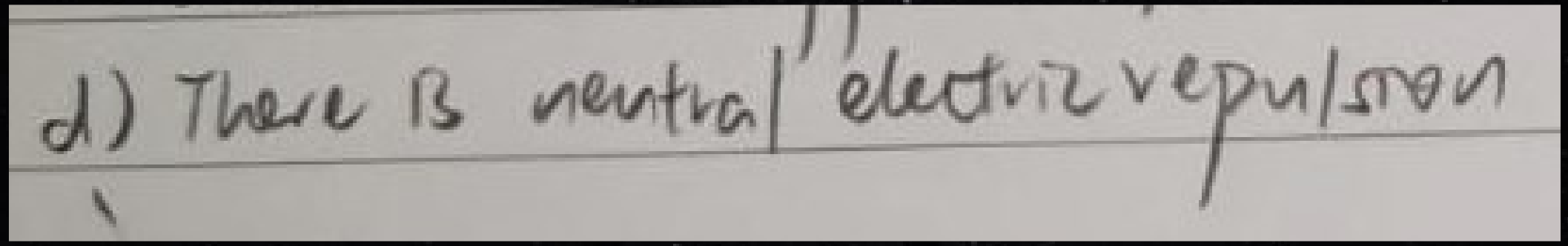
(d). When charged particles in low-density plasma come into contact, the charges interfere and electrostatic energy transfer is thus enabled.

(d) When the electron and ion in the plasma collide, a small fraction of the kinetic energy of the latter particle is transferred.

(d) The electrical energy from the charged particle converts into kinetic energy of a particle in the low-density plasma when they collide. The kinetic energy of this particle in the low-density fluid would then cause it to collide with other particles in the fluid, thus increasing the ~~heat~~ thermal energy in the fluid.

COLLISIONLESS Energy Transfer

- Answer deserving an honourable mention:



- What exactly is *neutral electric repulsion...?*

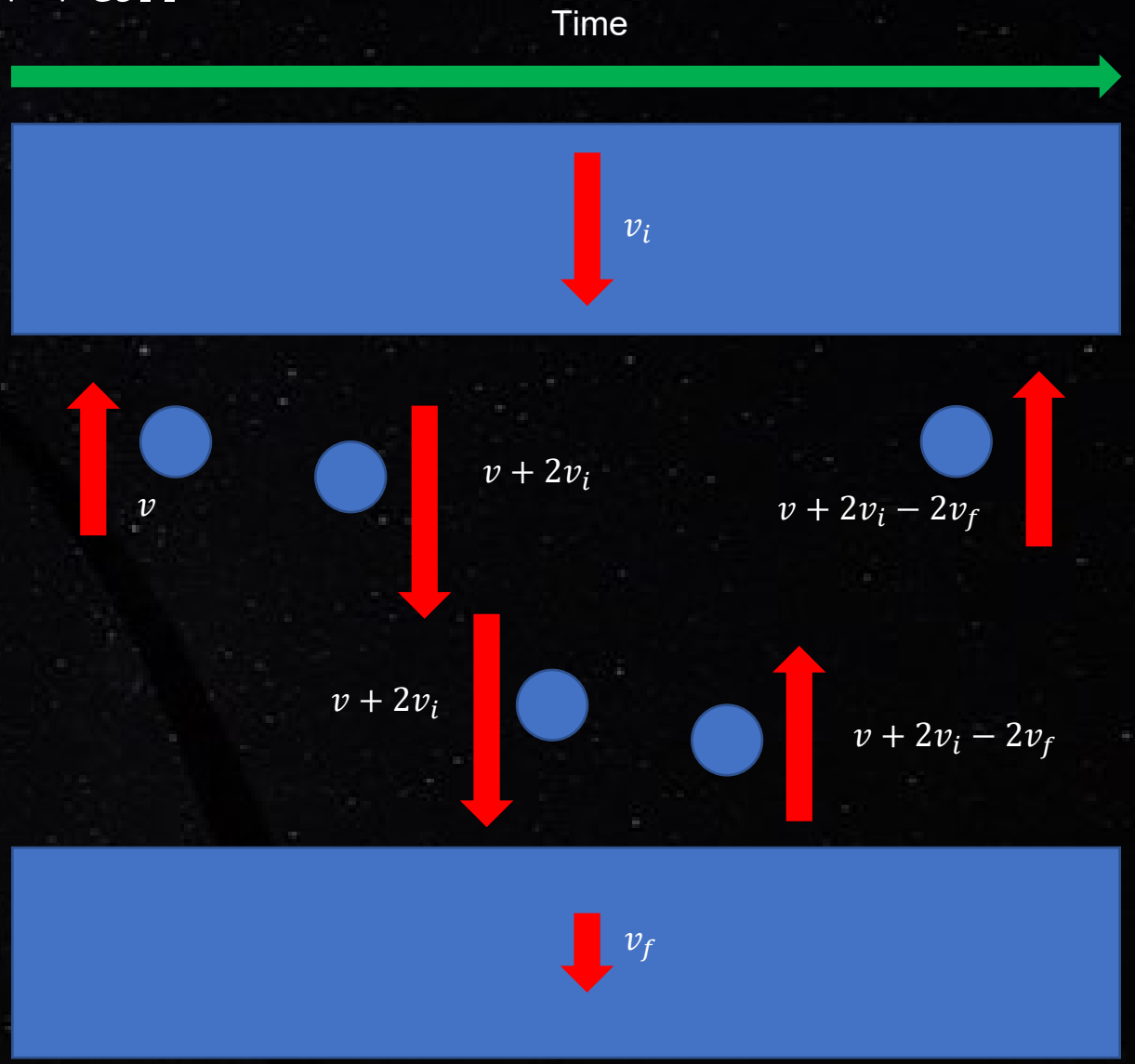
Mirror, Mirror, Or The Wall

- Explain perpetual bouncing + speed increase
  - What you did: Explain just one of the two.

- Easiest method:
  - Interweave explanation with calculations.

Mirror, Mirror, Or The Wall

- Let v be initial particle speed.
- After first collision:
  - Velocity: $v + 2v_i$ downwards.
- Second collision:
  - $v + 2v_i > v_f$: rebound!
  - After: $v + 2v_i - 2v_f$ upwards.
- Bouncy ball:
  - $v + 2v_i - 2v_f > v$
  - Thus will bounce perpetually!

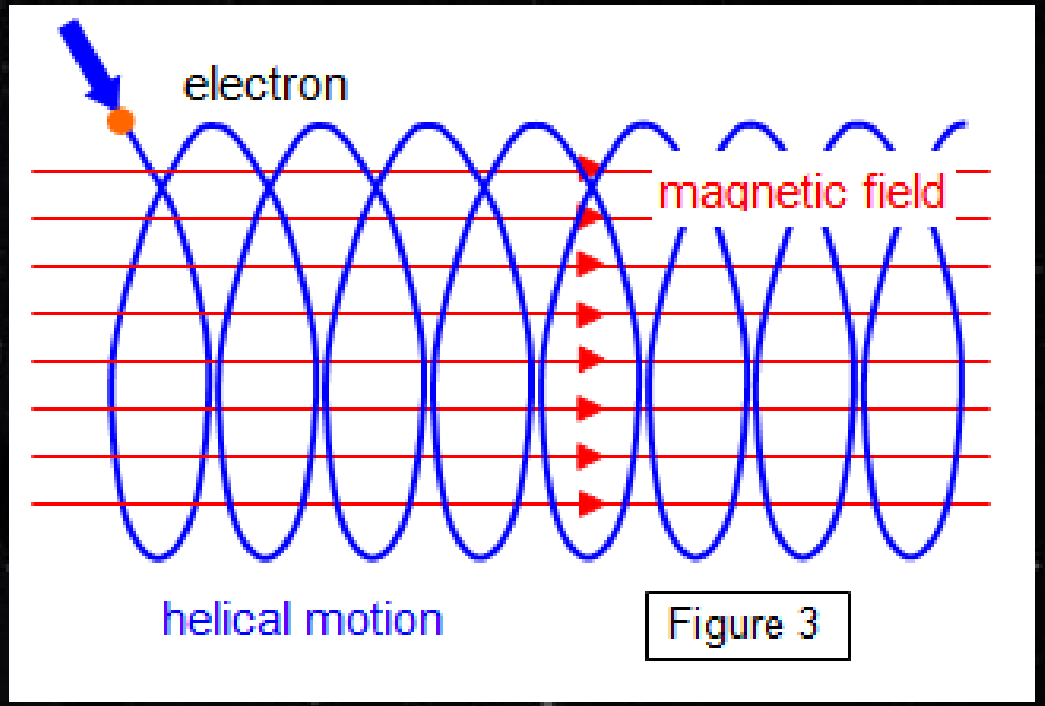


Particles Without Borders

- Question: Explain why charged particle crosses the boundary of magnetic reconnection.

- Key point:
  - Charged particles spiral along B field lines!

- Other possible answers:
  - Changing B field, high kinetic motion, etc.



Part III: A Certain Shocking Accelerator

- Title says all:
  - Magnetic reconnection acts as a shock
  - And it accelerates particles
- What you did right:
  - Know where cosmic rays come from.
    (…Mostly.)
- What you did wrong:
  - Math.
  - …Or lack thereof.

Cosmic Rays: The Free Gift of Marks

- Free marks!
  - Well, it's an easy question.

- Sources of cosmic rays:
  - Supernovae, CMEs, solar wind, blazars, etc.
  - Note: "Sun" too general, have to identify solar flares/solar wind/CMEs.

Cosmic Rays: The Free Gift of Marks…Mostly

not sure what a cosmic ray is.
but may be the charged particle.

g) idk stars? like the sun?
and supernovae. help.

g) Super Nova and Big Bang.

a black hole that is
accreting matter, i.e. Sirius

g) Supernovaes and Jet streams from poles of, ~~accretion~~

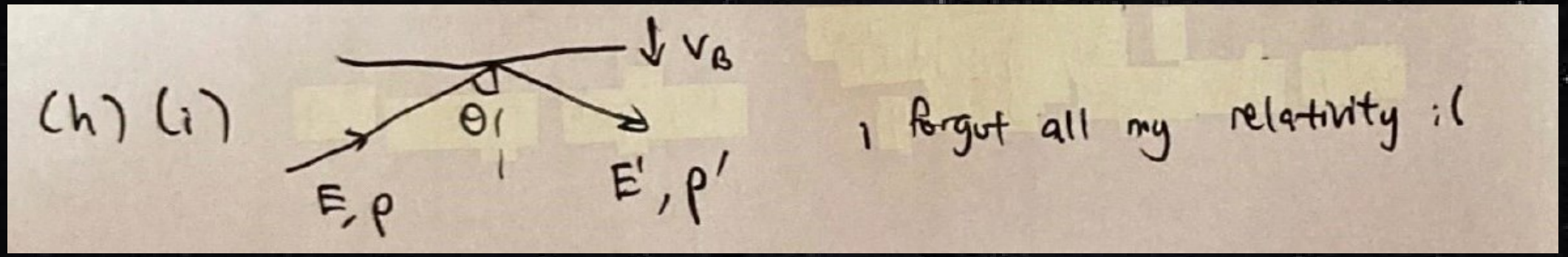
Relativistic Energy **GAINS**!

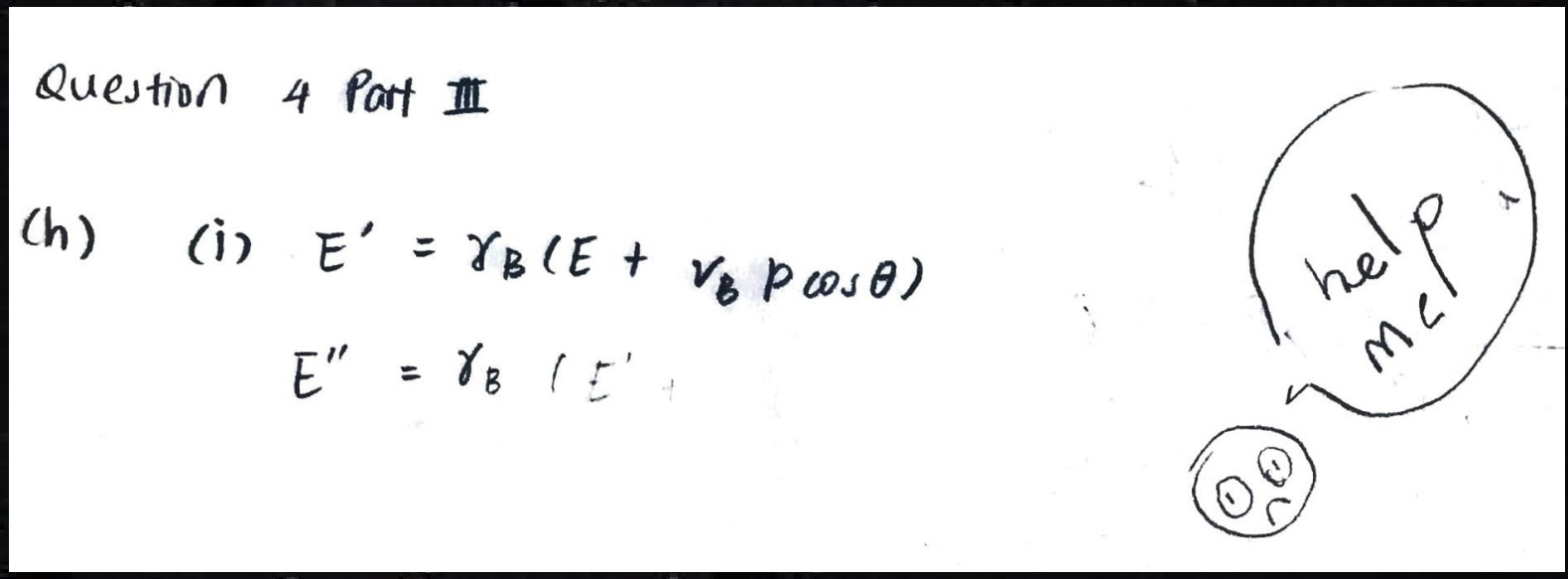
- Bonus part:
  - You are given the final energy E''!
  - Use Lorentz transforms to show.

- You are asked for an estimate of $\frac{\Delta E}{E}$…
  - Free mark: Simply plug in $\Delta E = E'' - E$ and get a final expression.
    - Many did not even do this!
  - The rest is details using the hint and conditions of the question.

Relativistic Energy **GAINS**!

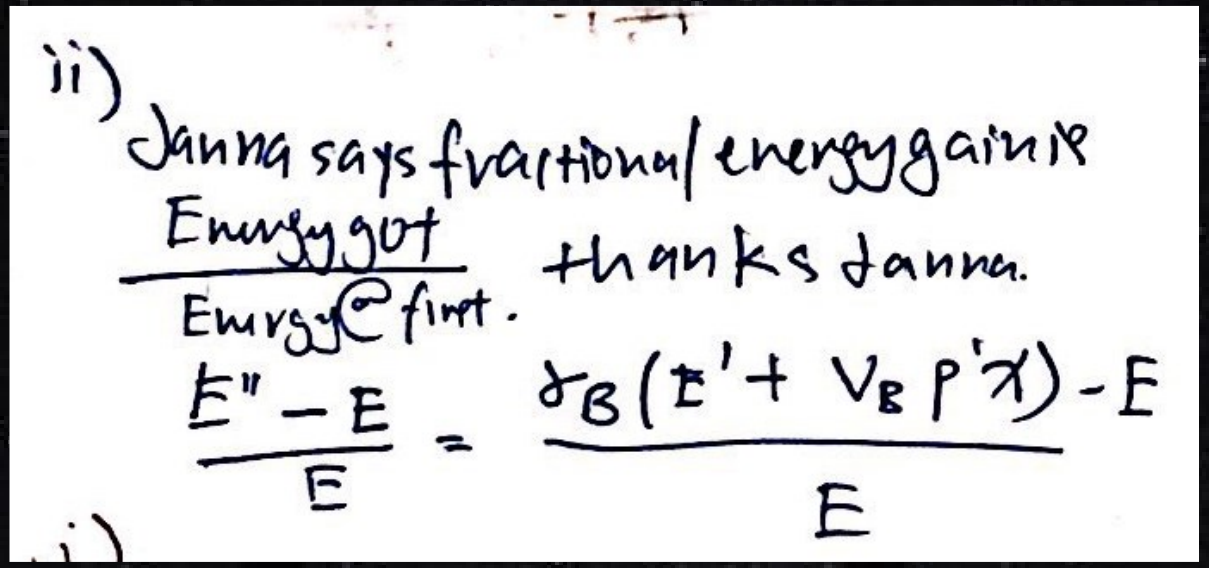
- Bonus part: A summary of answers.





Relativistic Energy **GAINS**!

- The correct way to start estimating $\frac{\Delta E}{E}$, by Janna:



Probably Probabilistic

- Find average fractional energy gain $\left\langle \frac{\Delta E}{E} \right\rangle$.
  - Was meant to be an okay question but…

- How to get this mark:
  - $\frac{\Delta E}{E}$ depends on angle of approach θ.
  - Probability of finding particle at angle between $\theta + d\theta$ is $p(\theta)$, for $0 \leq \theta \leq \frac{\pi}{2}$.
  - Simply integrate: $\int_0^{\frac{\pi}{2}} \frac{\Delta E}{E} p(\theta) d\theta$.

When You Give Up (With Probability 1):

(j) $\left\langle \frac{\Delta E}{E} \right\rangle = \frac{\Delta E}{E} \div \frac{3}{2}\cos\theta$ HAHAH

$= \frac{2v_B \cos\theta}{c} \times \frac{2}{3\cos\theta}$ grrr

$= \frac{4v_B}{3c}$

4j) $\left\langle \frac{\Delta E}{E} \right\rangle = \int_{\theta=0}^{\pi/2} \frac{2v_B \cos\theta}{c} d\theta \times \frac{1}{\pi/2}$

$= \frac{4}{\pi} \cdot \frac{1}{c} v_B \int_0^{\pi/2} \cos\theta \, d\theta$

$\approx \frac{4v_B}{3c}$ since $\pi \approx 3$

j) average probability is $\frac{1}{2}$.

j) $\left\langle \frac{\Delta E}{E} \right\rangle = \left\langle \frac{2v_B \cos\theta}{c} \right\rangle$

$= \left\langle \frac{2v_B}{c} \left(\frac{2}{3}\right) \right\rangle$

$= \left\langle \frac{4v_B}{3c} \right\rangle$ (shown)

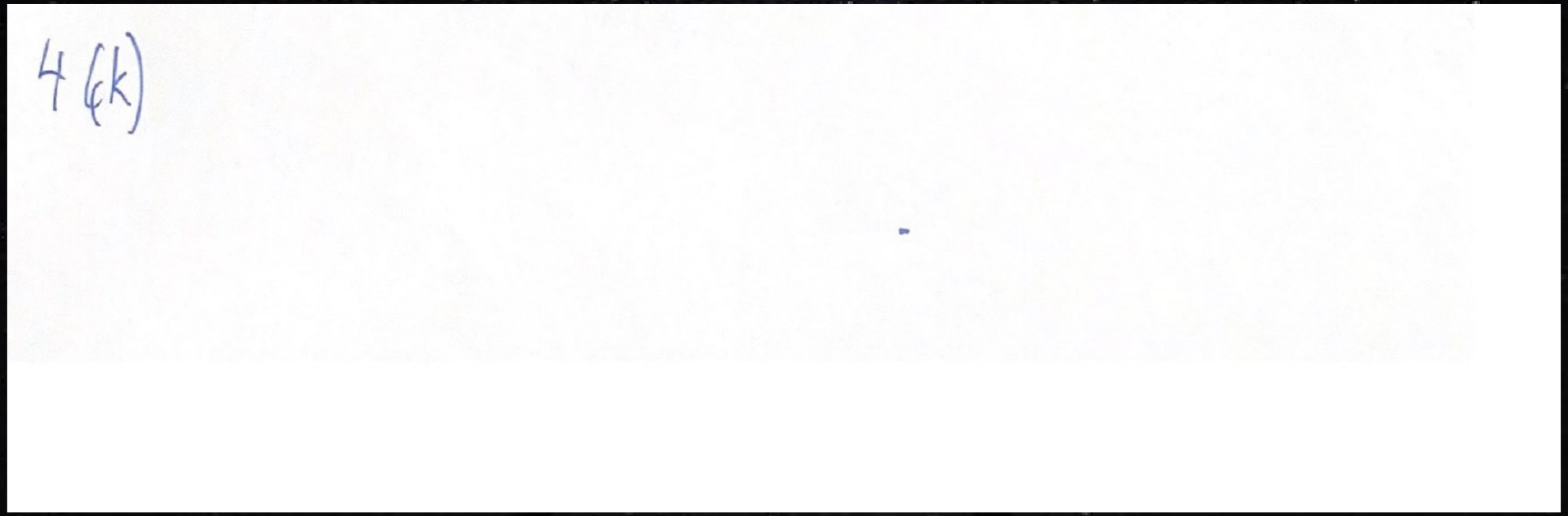
~~Space~~ Spectrum: The Final ~~Frontier~~ Killer

- Deduce a naïve version of the cosmic ray energy spectrum.
  - Hard question!

- Have to combine various ingredients:
  - Proportion of particles remaining after k collisions.
  - Average energy of particles after k collisions.
  - Big brain math manipulation.
  - First-order approximation.

~~Space~~ Spectrum: The Final ~~Frontier~~ Killer

- A brief summary of answers:



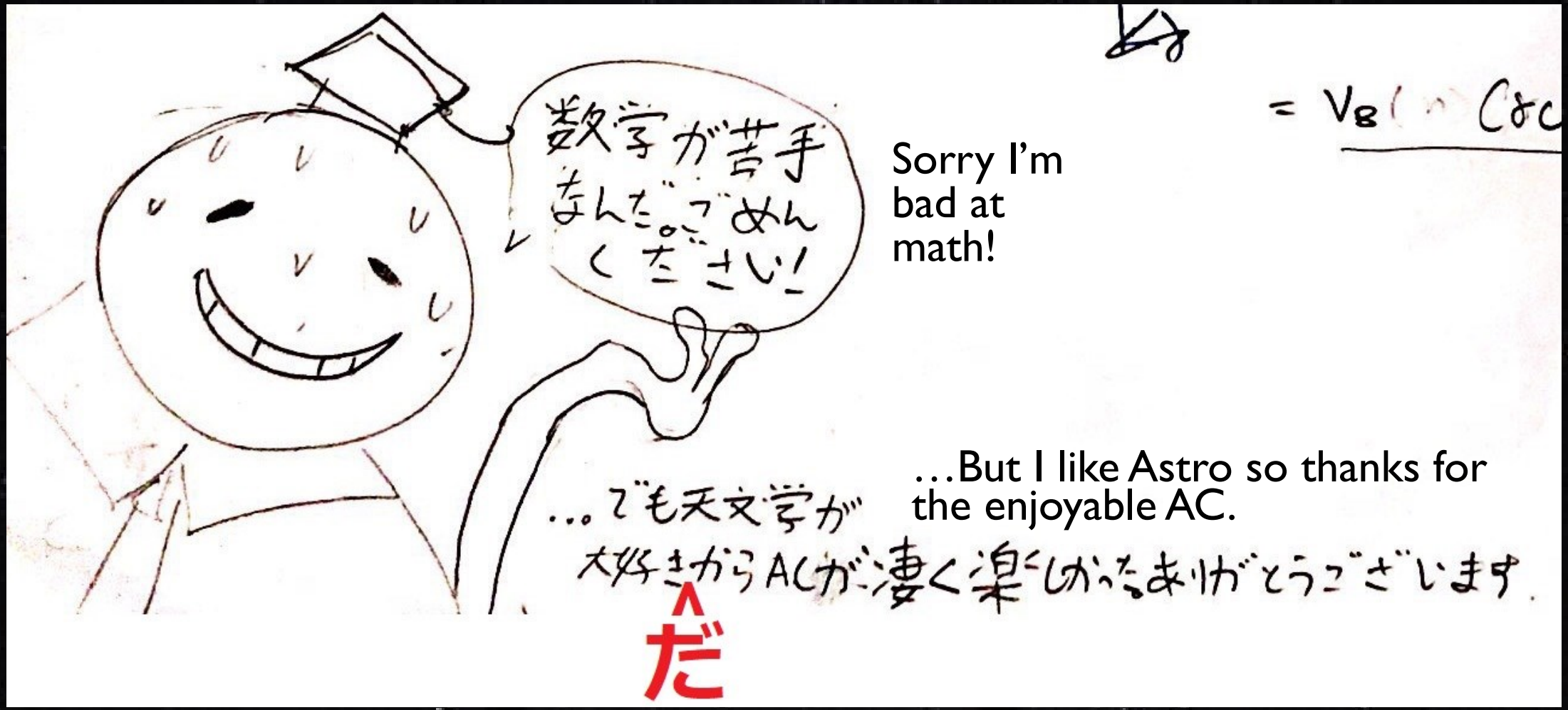
When You Give Up: Japanese Edition

Ouch. I guess I'm dead after all.

going to be honest. 私も知らん

going to be honest. I don't know either.

Words to Live By

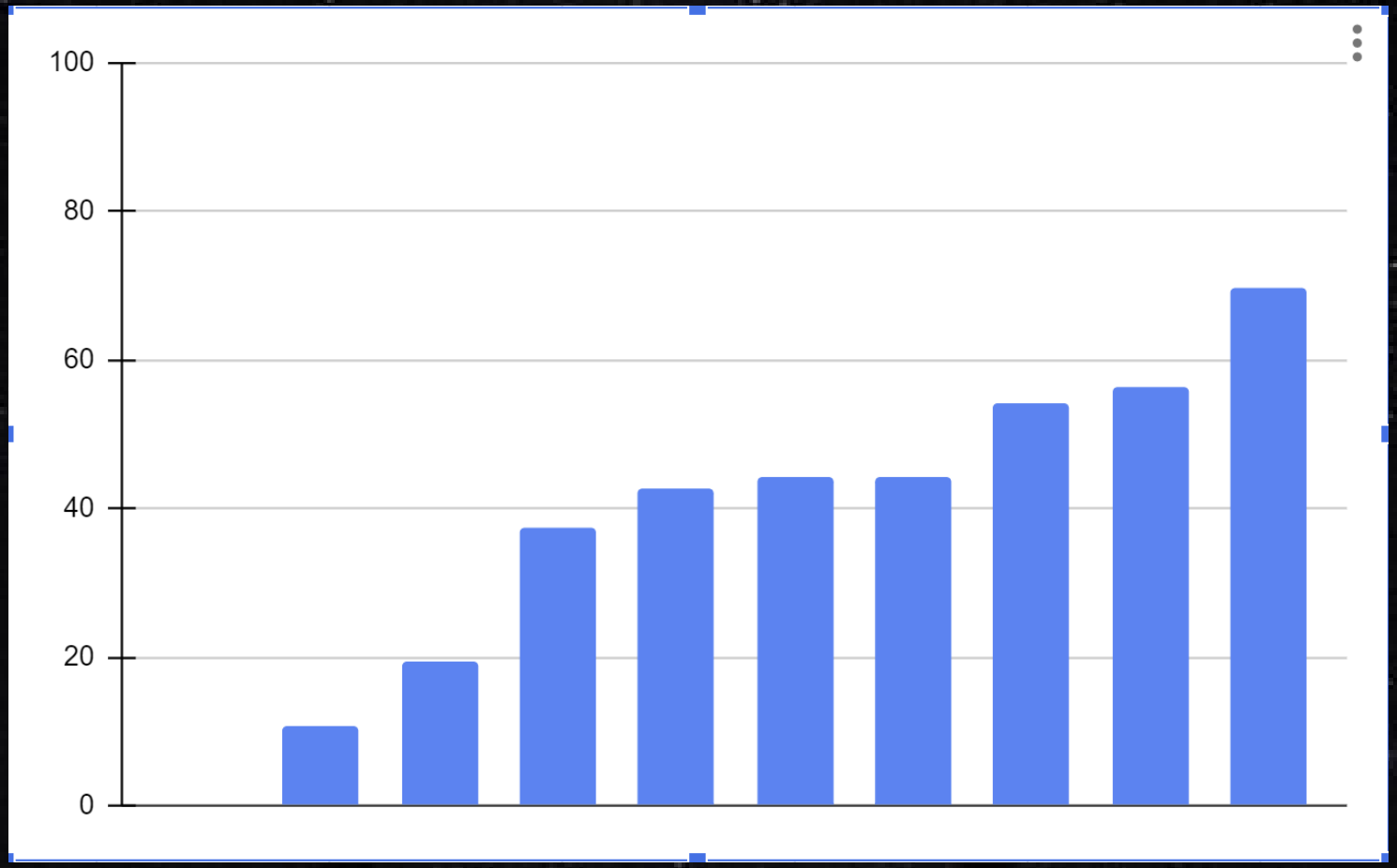


Sorry I'm bad at math!

…But I like Astro so thanks for the enjoyable AC.

Observation Round

Final Obs Score Distribution



Practical Observation

Q setter: Ryan

General Comments

- Considering the difficulties in managing zoom remote control and all, all teams did a fair job.

Theoretical Observation

Q Setter: Ken Rui, NT, NP

General comments

- Most teams failed the equipment question.
- Some of you decided to draw extra stuff for the night sky question.

Findercharts

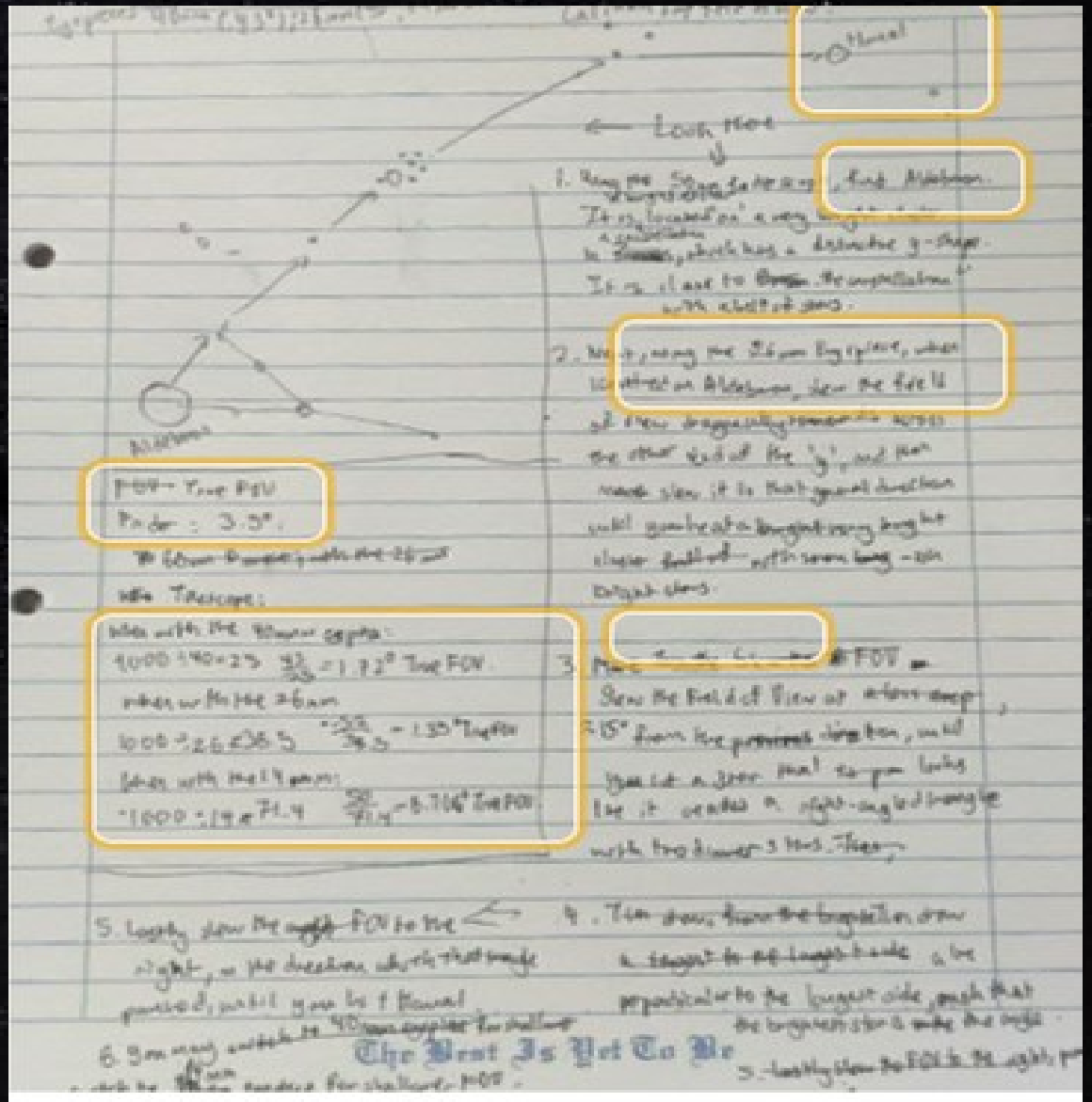
Q Setter: Nicholas T

Findercharts

- Aim is to be a quick reference so that you need not refer to a star atlas in order to find an obscure object quickly
- Despite holding this segment online is a new experience for us all, most of you adhered to instructions well.
- An attempt at making a Finderchart can be seen.

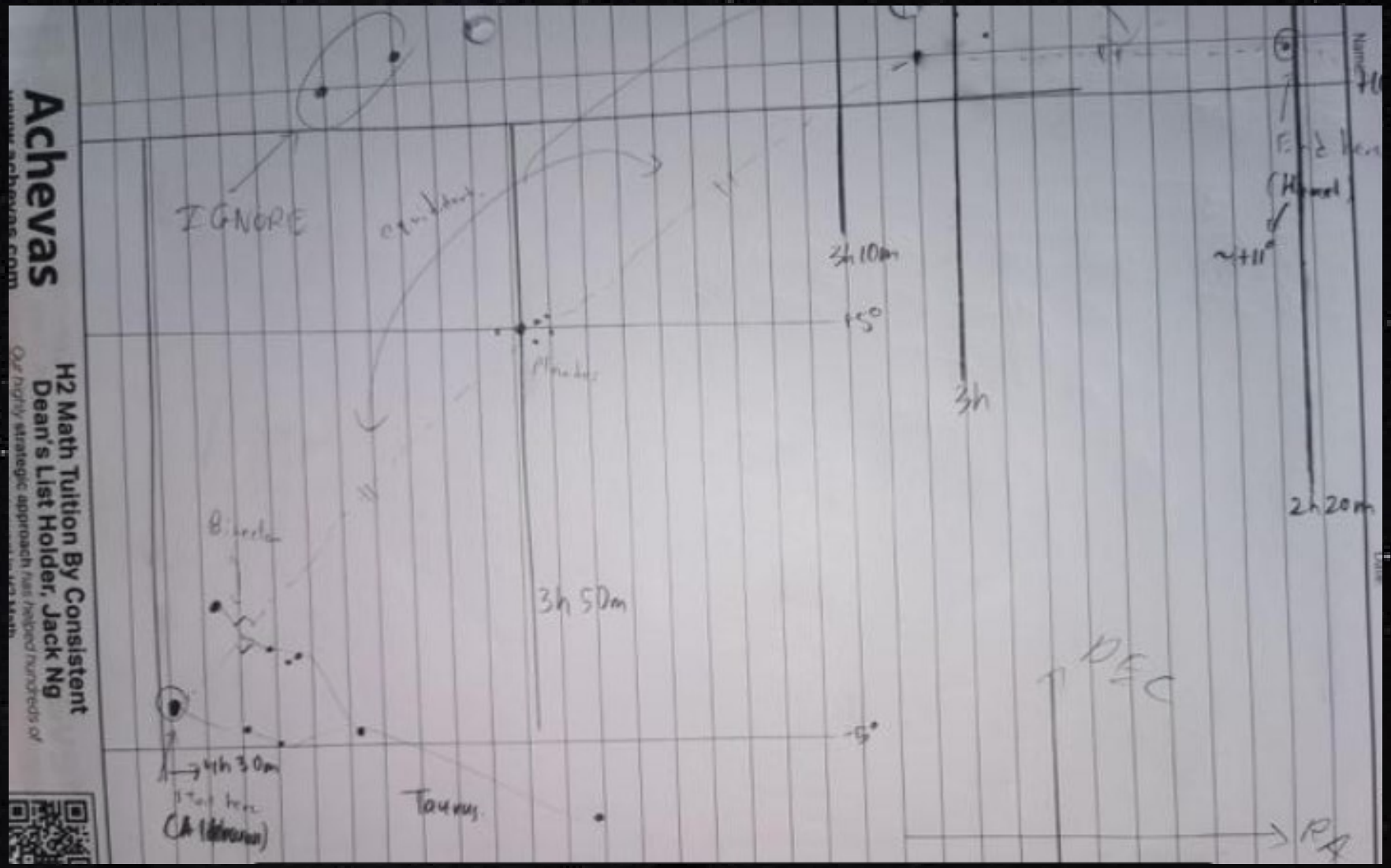
Findercharts

- Do you honestly expect your friends to be able to read everything here within 5 minutes?



Findercharts

- Apa ini?



Findercharts

- We asked for 1 photo. Some of you submitted 2 or 3....
  - What happens? Your score was divided into half

Findercharts

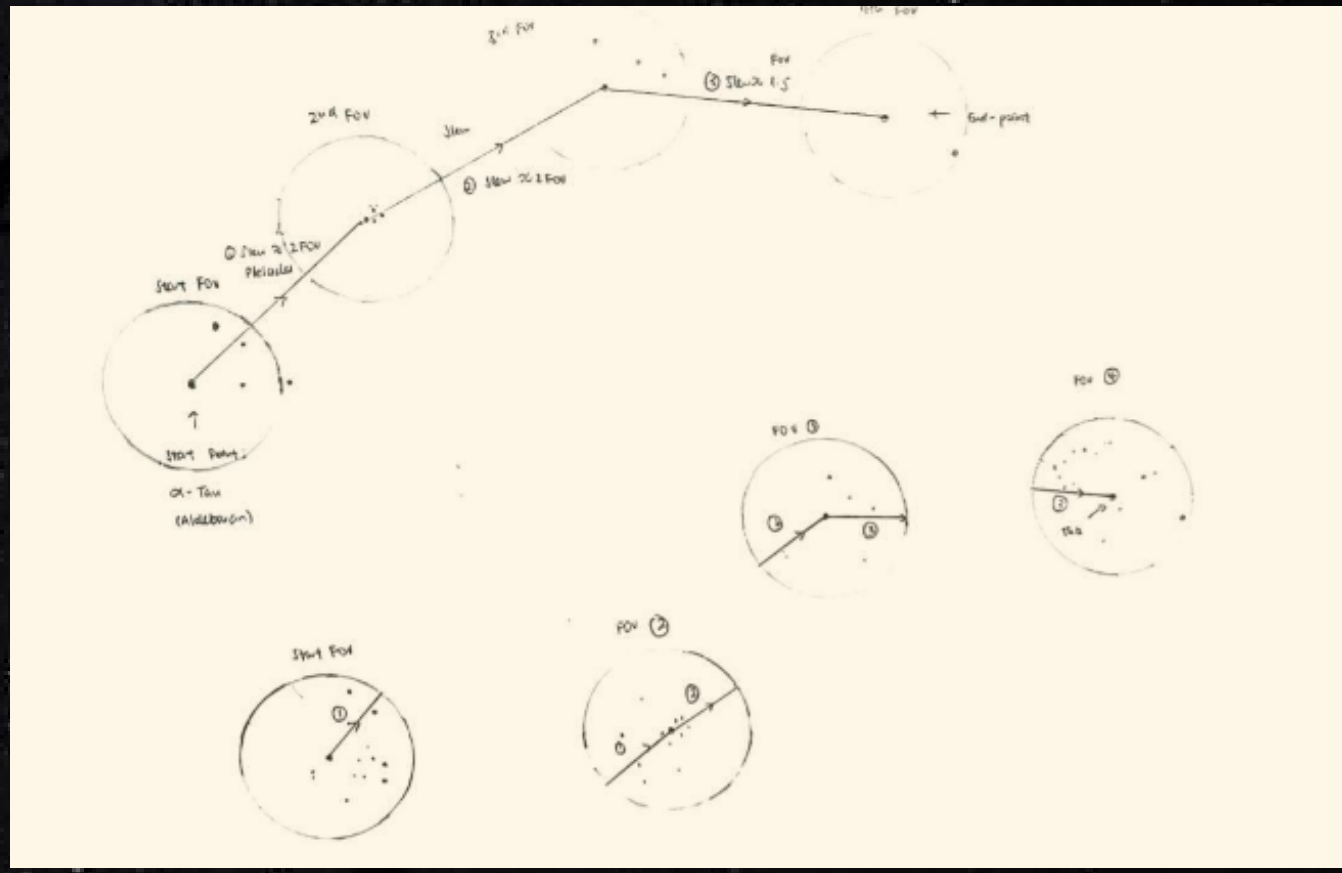
- We gave you this:

Component	Percentage (%)
Indication of Start and End Points	10
FOV Calculations	20
Instructions on Slew	30
Use of Finderscope	20
Accuracy of Drawing	20

Findercharts

- Where are your FOV calculation workings?

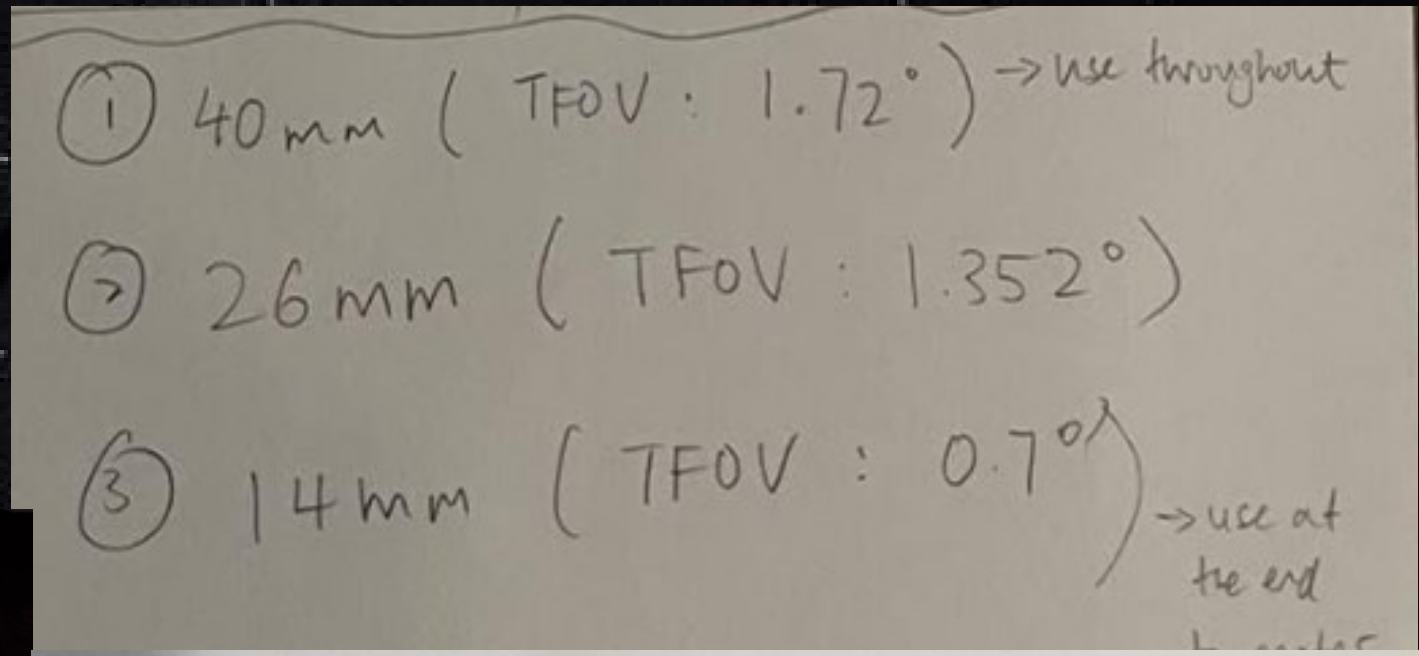
Component	Percentage (%)
Indication of Start and End Points	10
FOV Calculations	20
Instructions on Slew	30
Use of Finderscope	20
Accuracy of Drawing	20

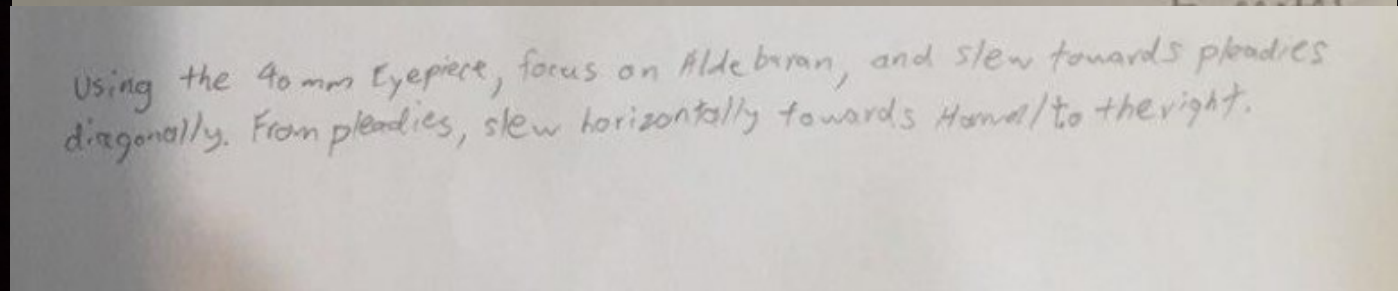


Findercharts

- Why would you explicitly tell your teammates to lose the finderscope?

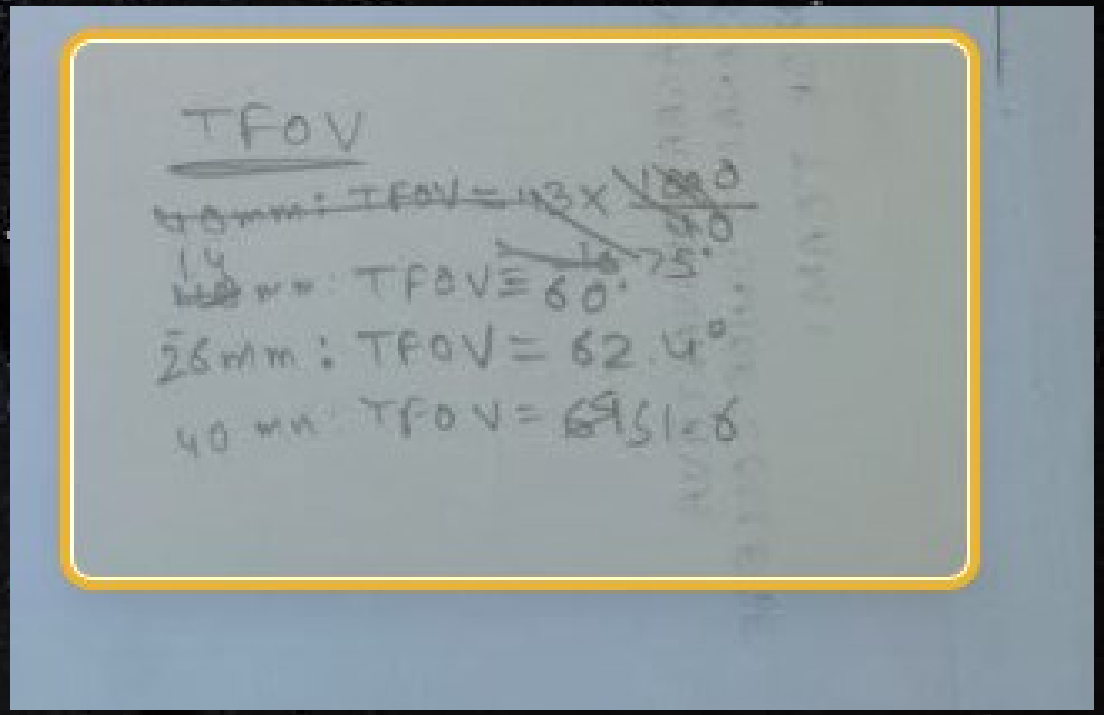
Component	Percentage (%)
Indication of Start and End Points	10
FOV Calculations	20
Instructions on Slew	30
Use of Finderscope	20
Accuracy of Drawing	20





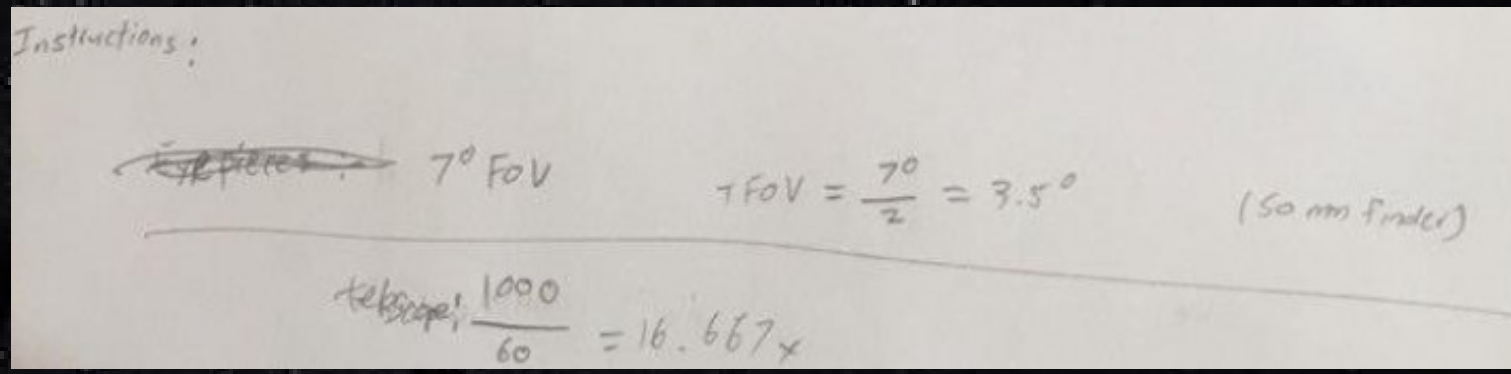
Findercharts

- Fov Calculations done
- Except... does it make sense?
- TFOV = 60 degrees??



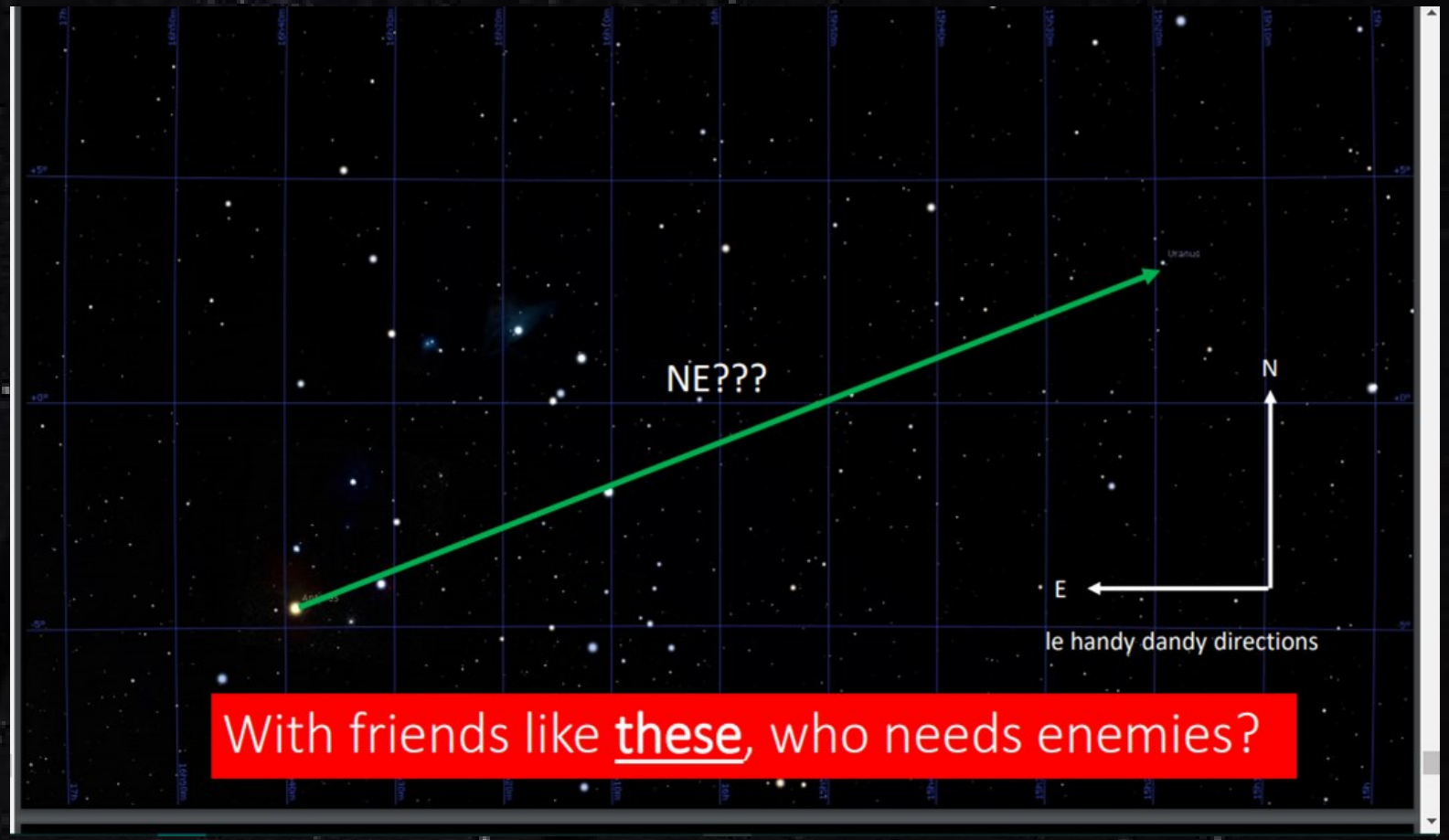
Findercharts

- Finderscope FOV is already given...
- Instead: take the number divide by 2...



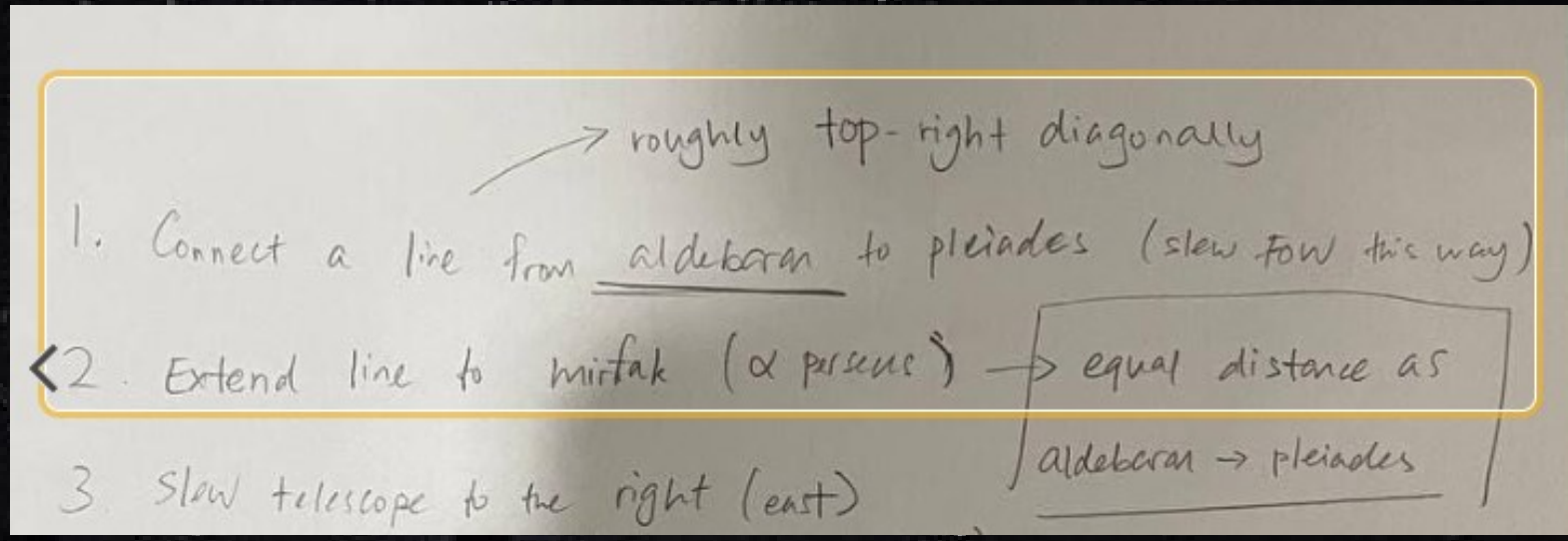
Findercharts

- Instructions must be clear: Remember this from back in 2018?



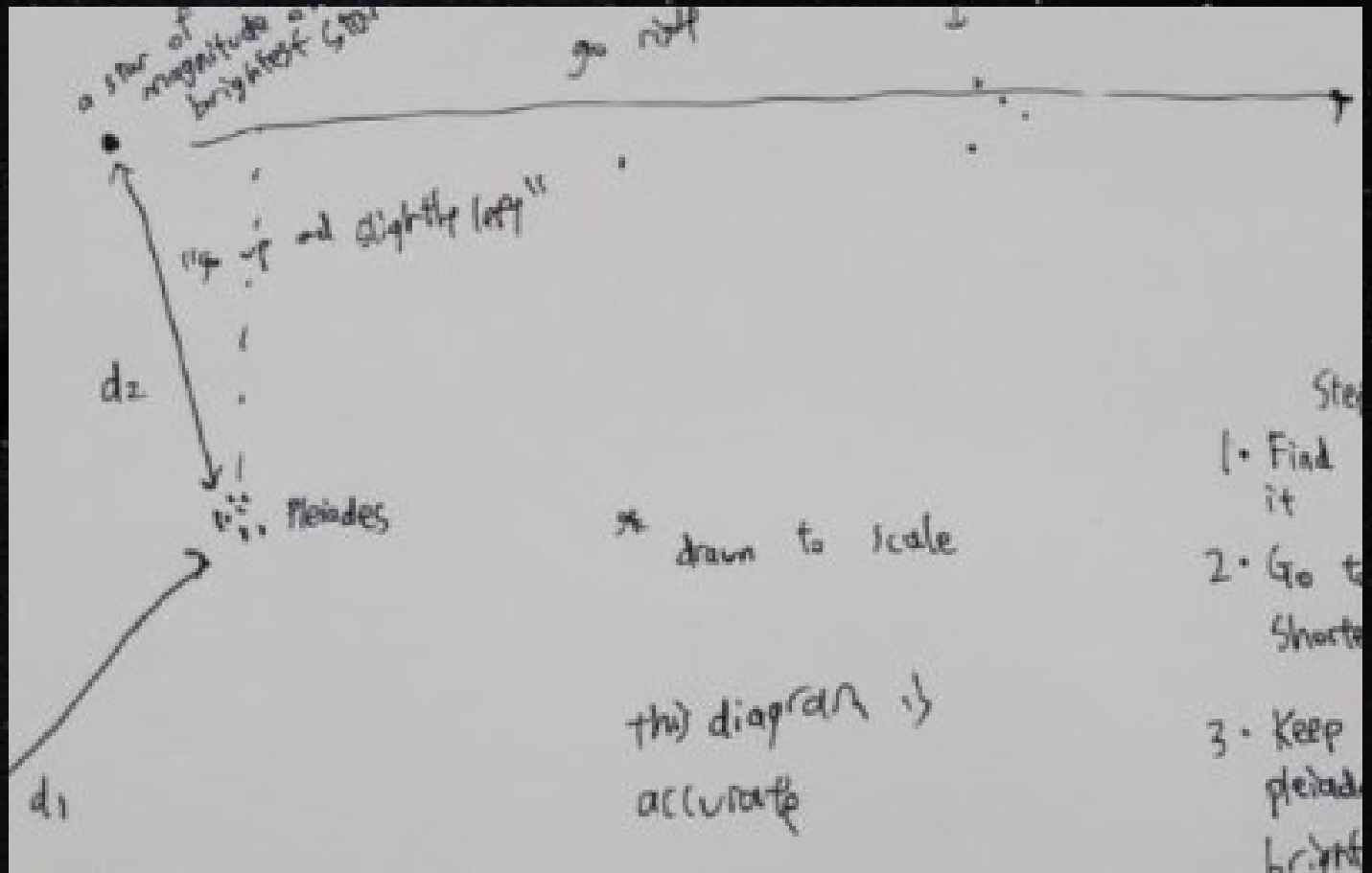
With Friends like these...

- Your friends gave you this to solve...
- Issues listed:
  - "Top Right" is for you or for them?
  - What "line" are you referring to
  - What does "Slew FOV this way" mean to them?
  - Will they know which star is mirfak?



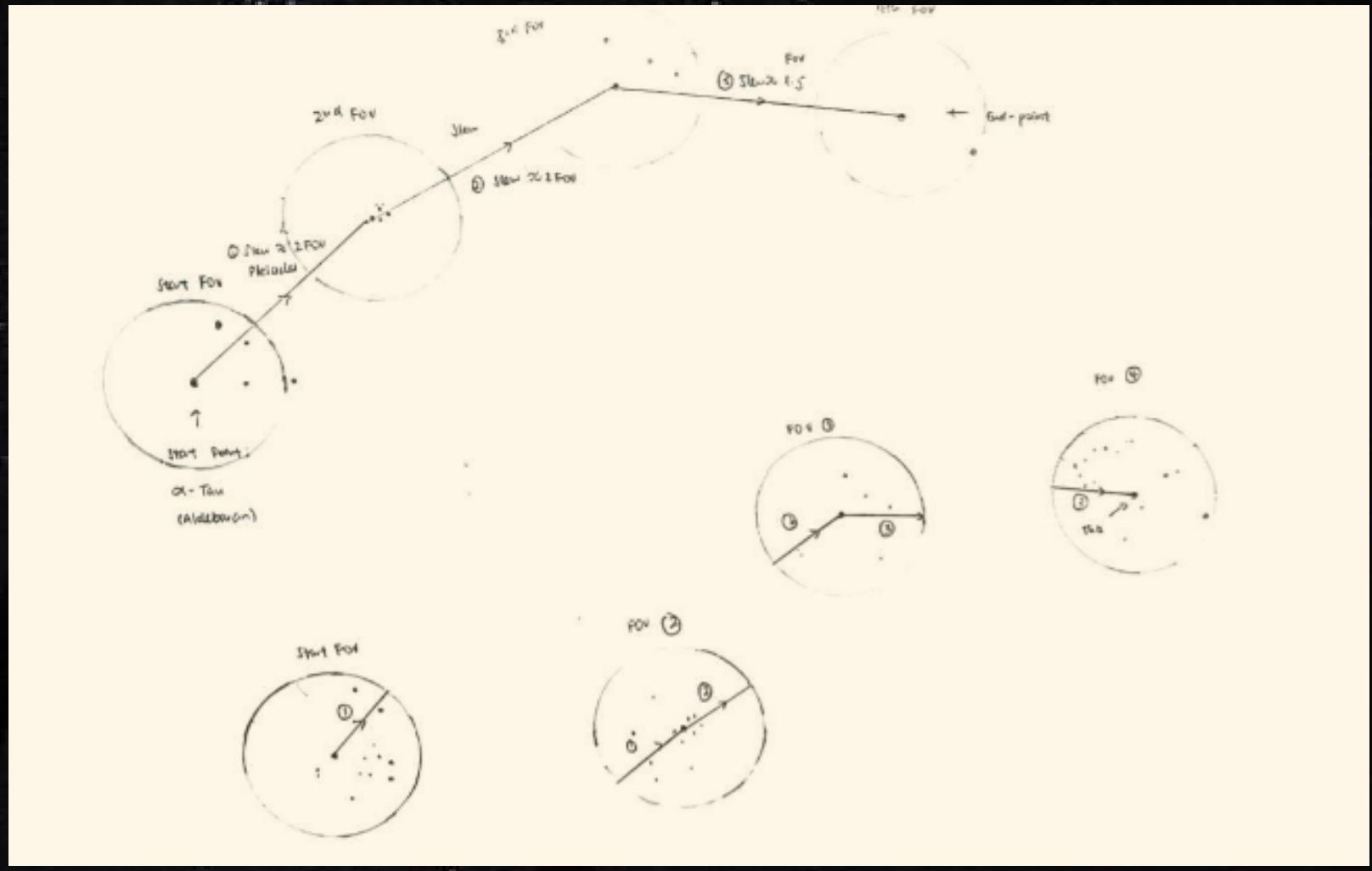
With Friends like these...

- Your friends gave you this to solve...
- Issues listed:
  - Self-Claimed accurate diagram



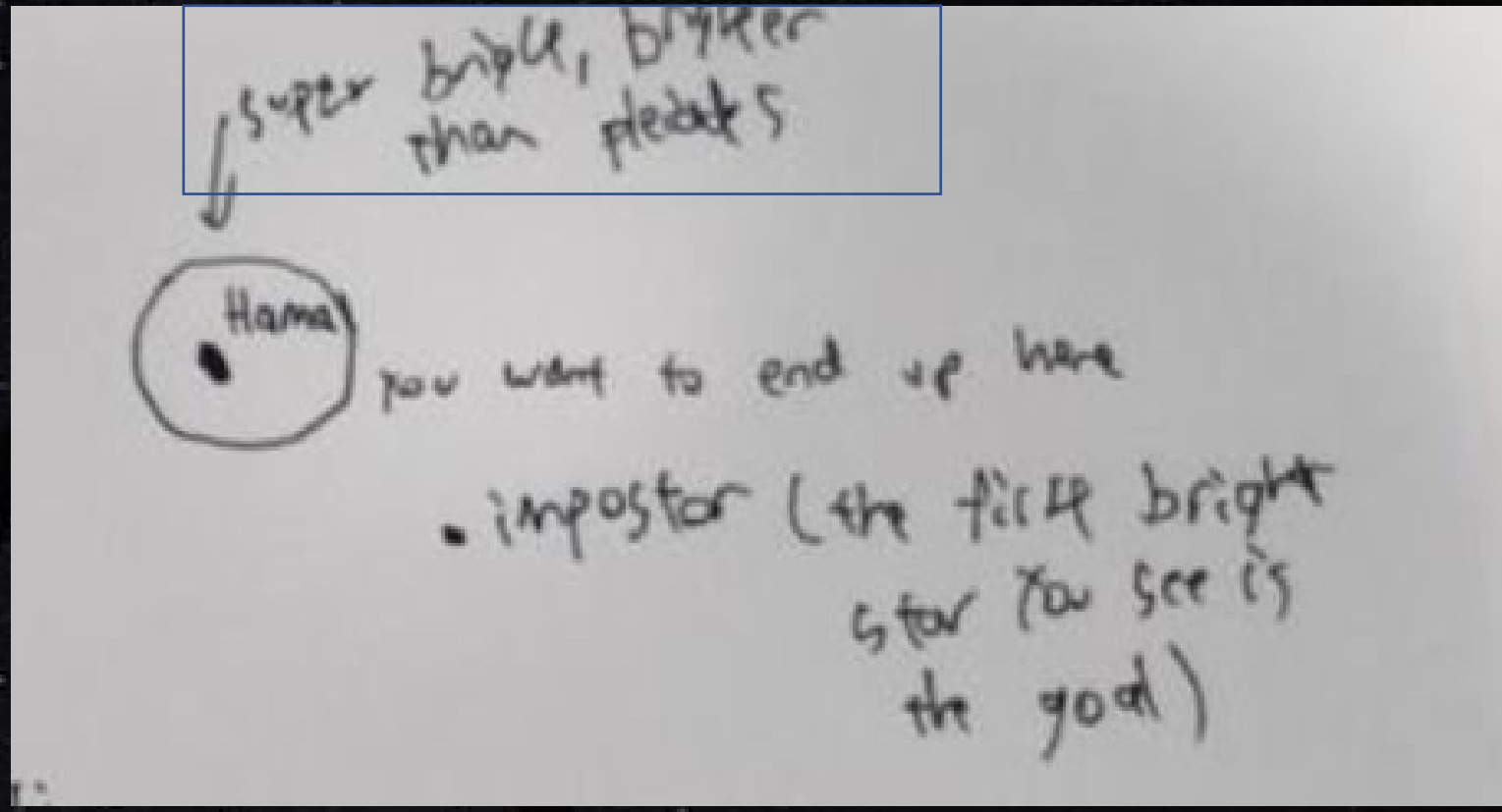
With Friends like these...

- If you told me this is accurate, I might believe you more.
  - However, this one has inherent problems in accuracy in it as well…



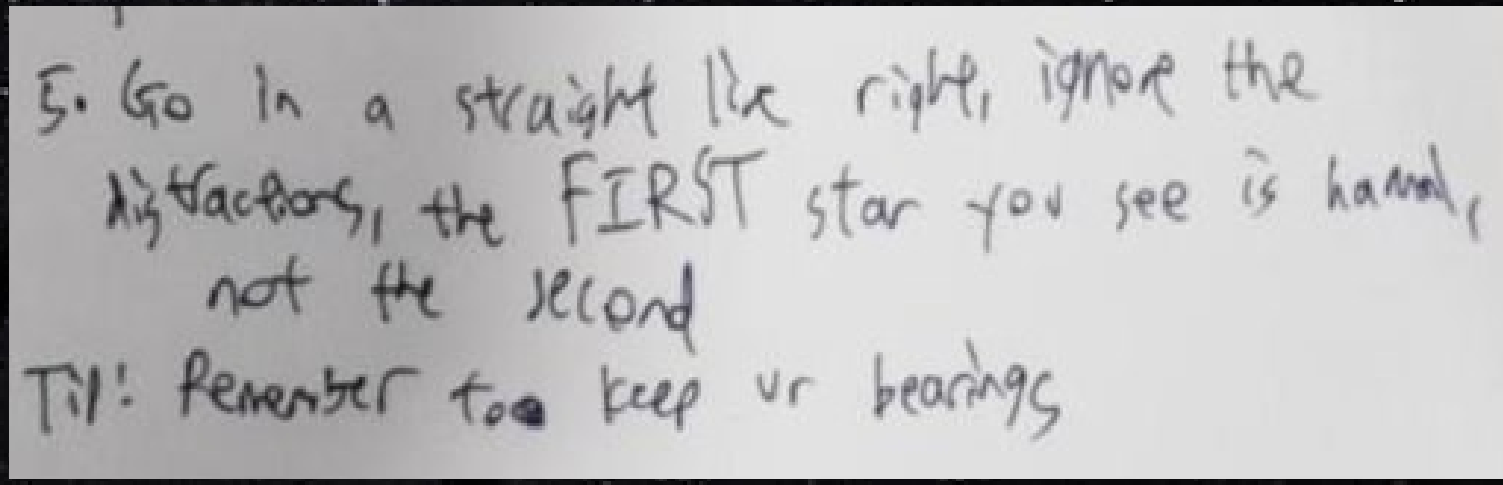
With Friends like these...

- Your friends gave you this to solve...
- Issues listed:
  - Misleading information



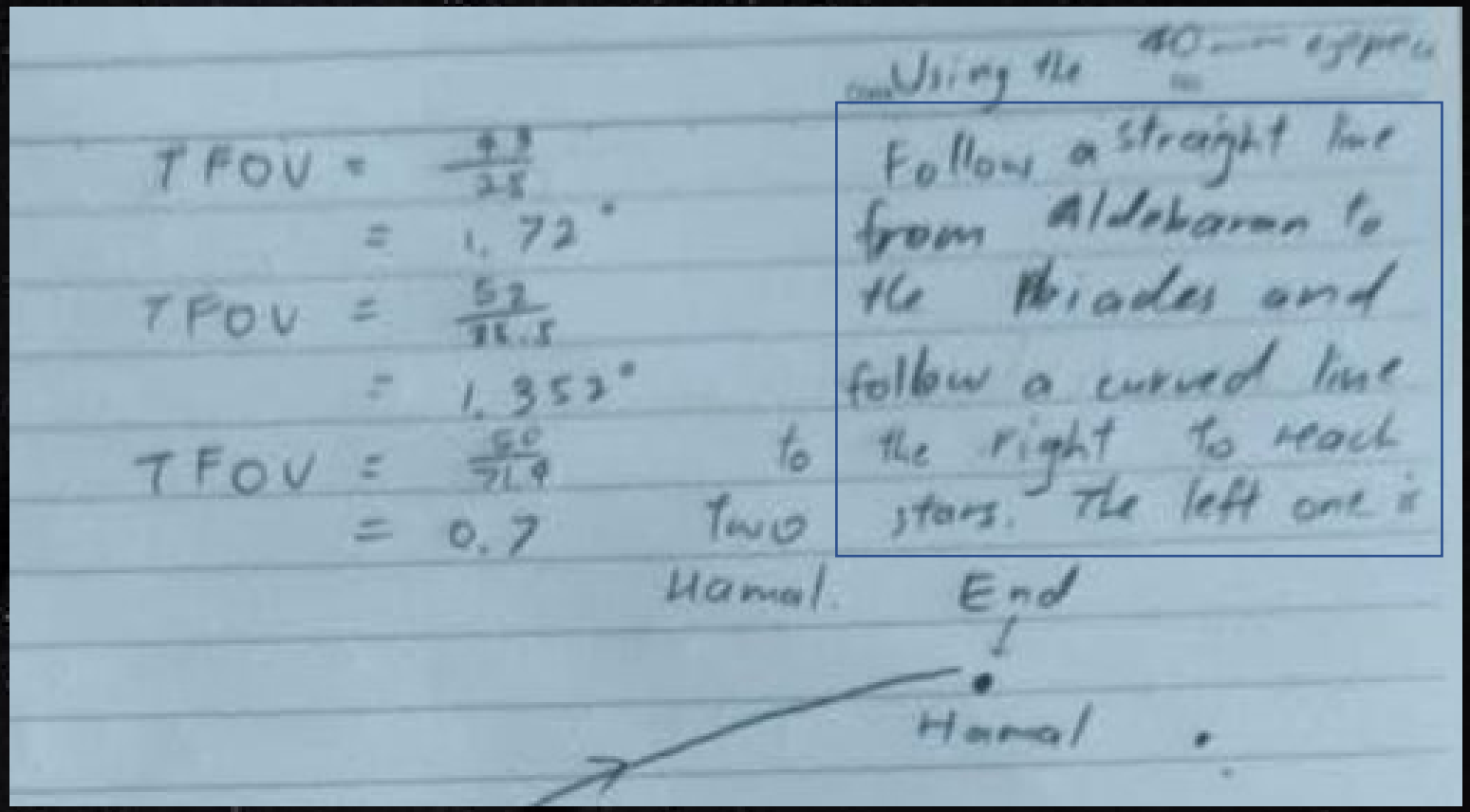
With Friends like these...

- Your friends gave you this to solve...
- Issues listed:
  - Instructions which are not particularly useful



With Friends like these...

- Your friends gave you this to solve...
- Issues listed:
  - Following a curved line? How would you do that?
  - FOV calculations not labelled



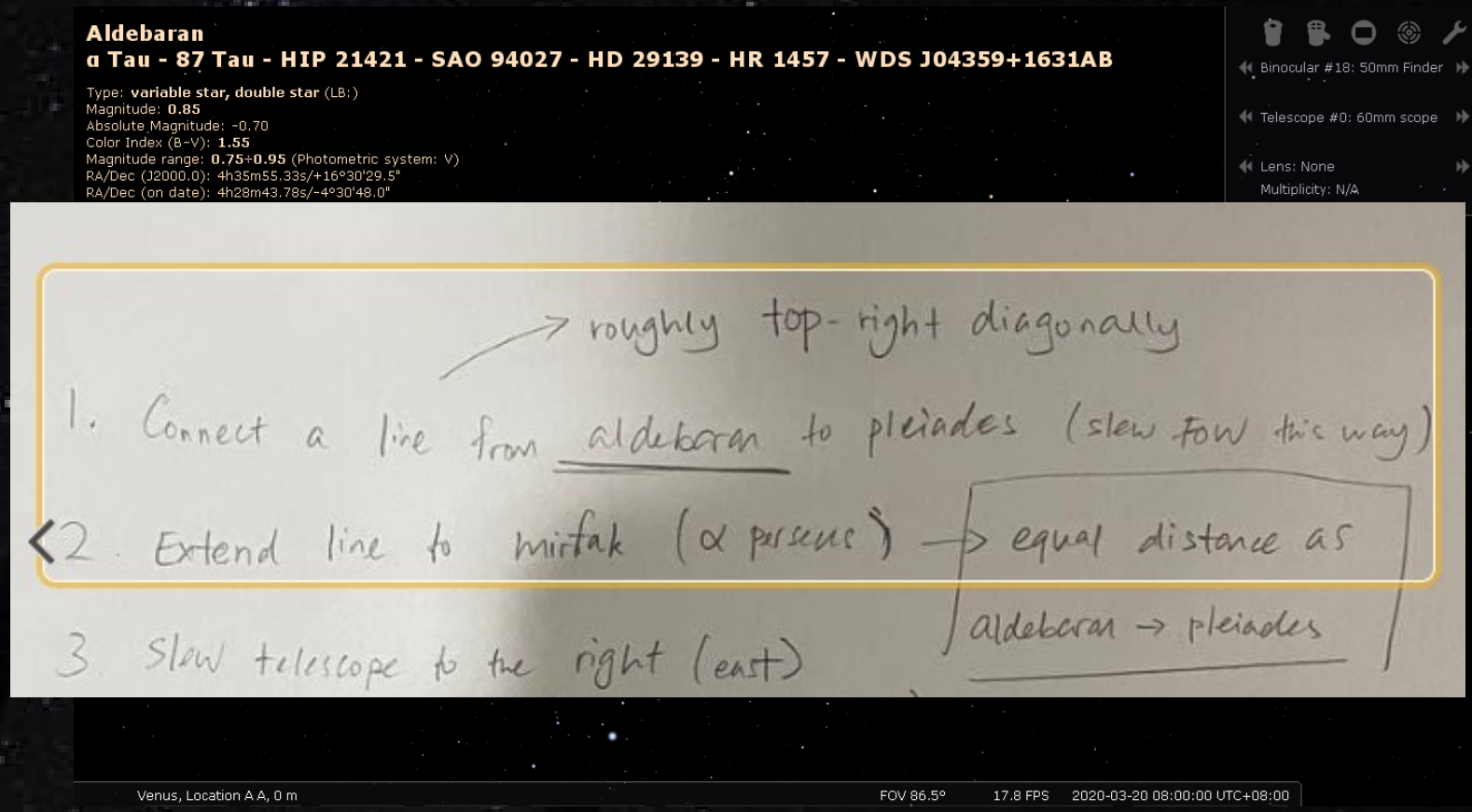
Who needs enemies?

What went wrong?

- This was what you were given

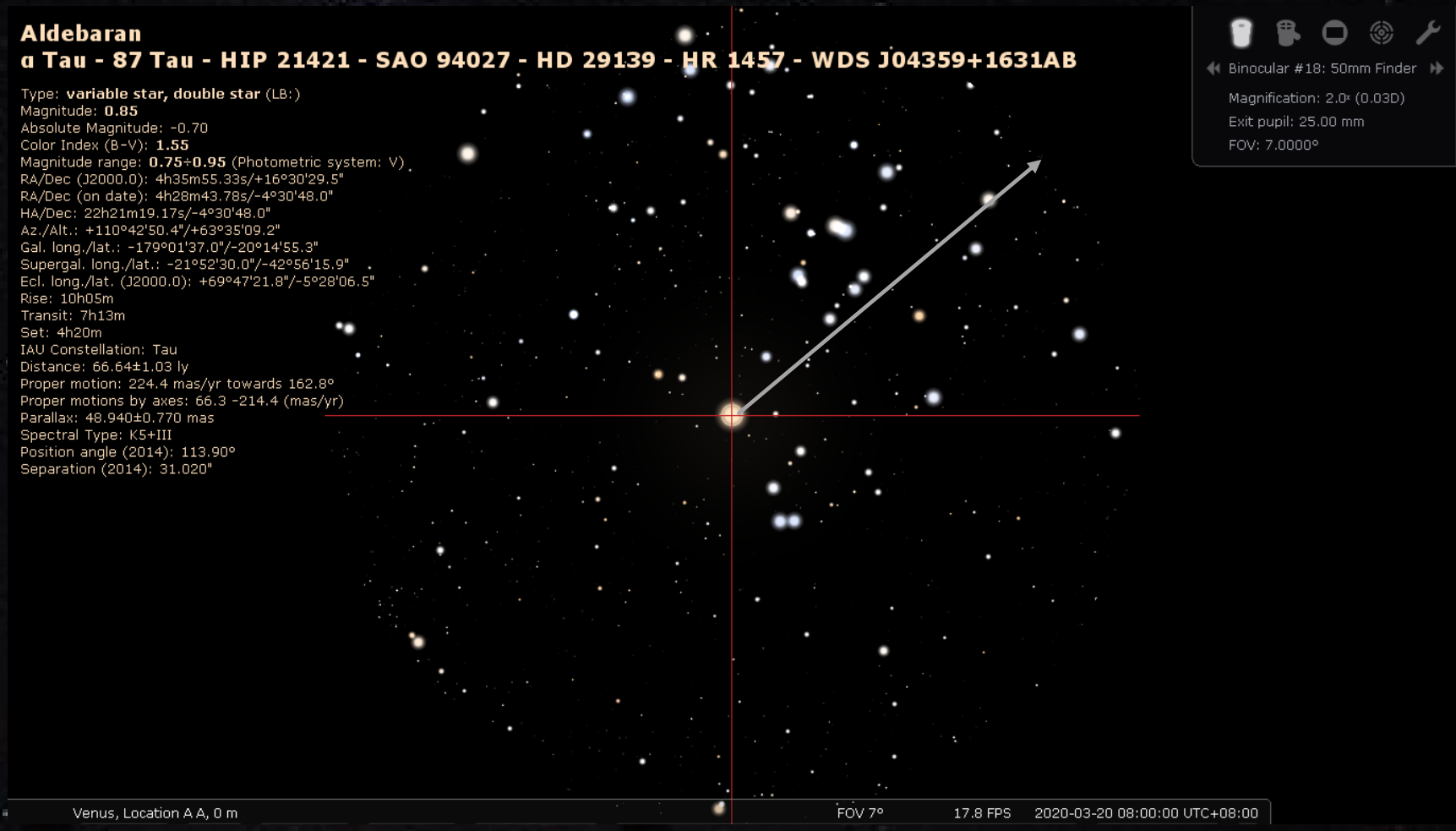
What went wrong?

- Remember me?



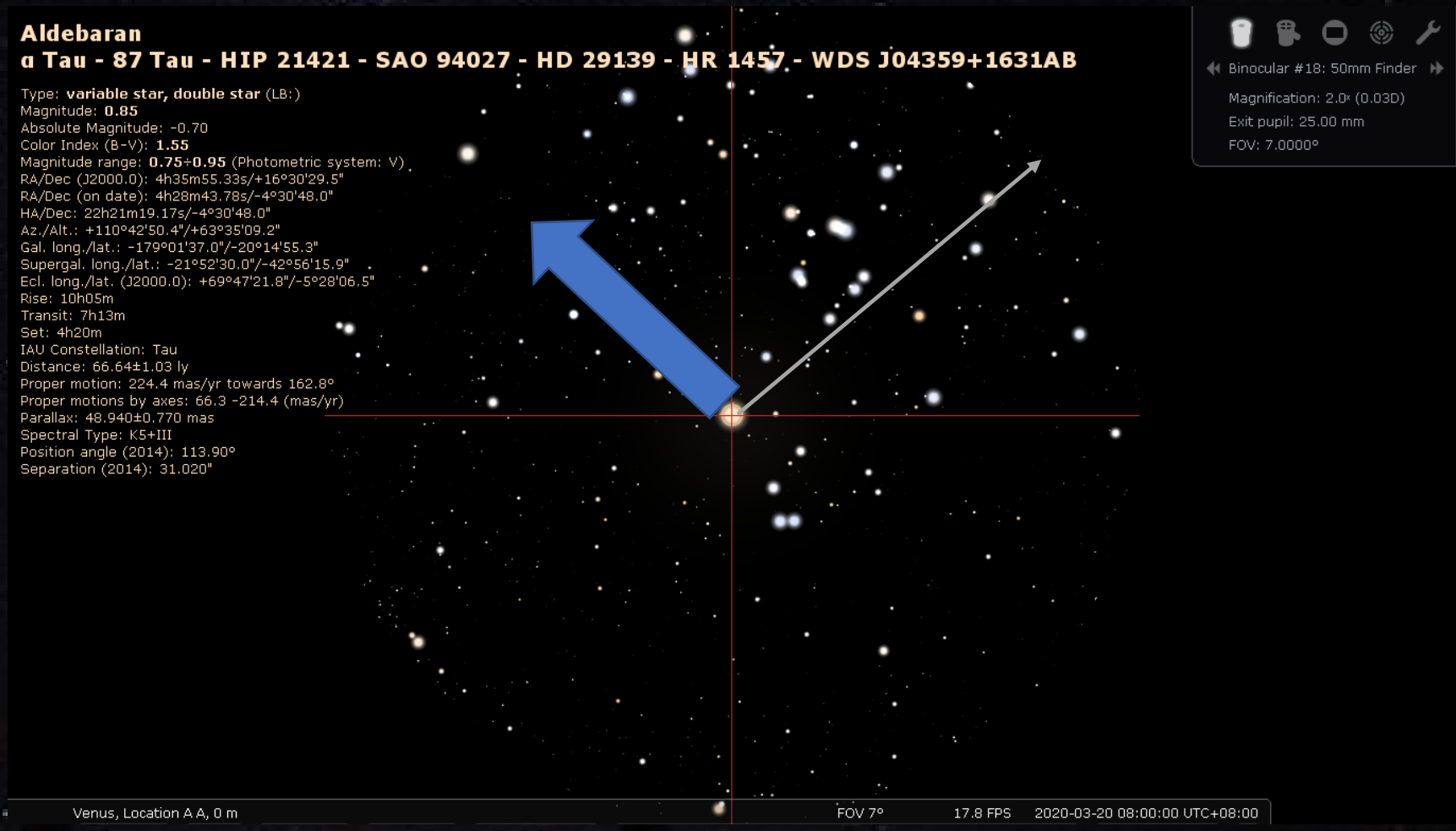
What went wrong?

- This is what your friends see
- Apa Ini "Top Right?"



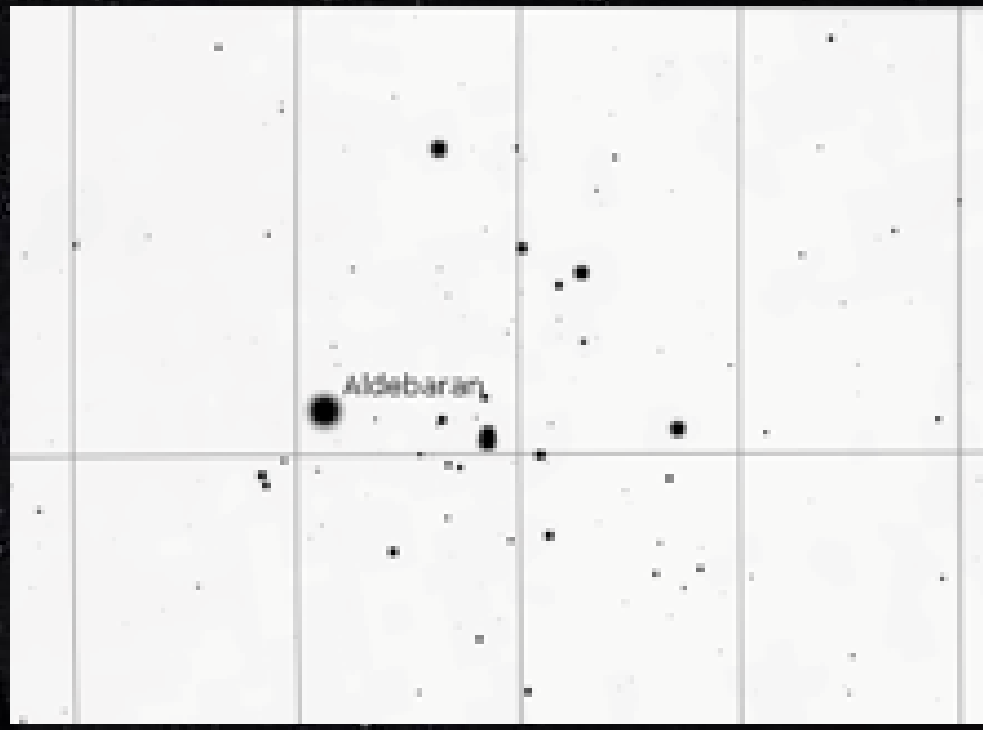
What went wrong?

- Where you actually wanted your friends to go...



Solution?

- Instructions must be useful to your friends.
  - Tell what you want them to find, label it well and clearly.
  - Tell what you want them to do.
  - Tell them what they should see at the start (actually draw it out) because



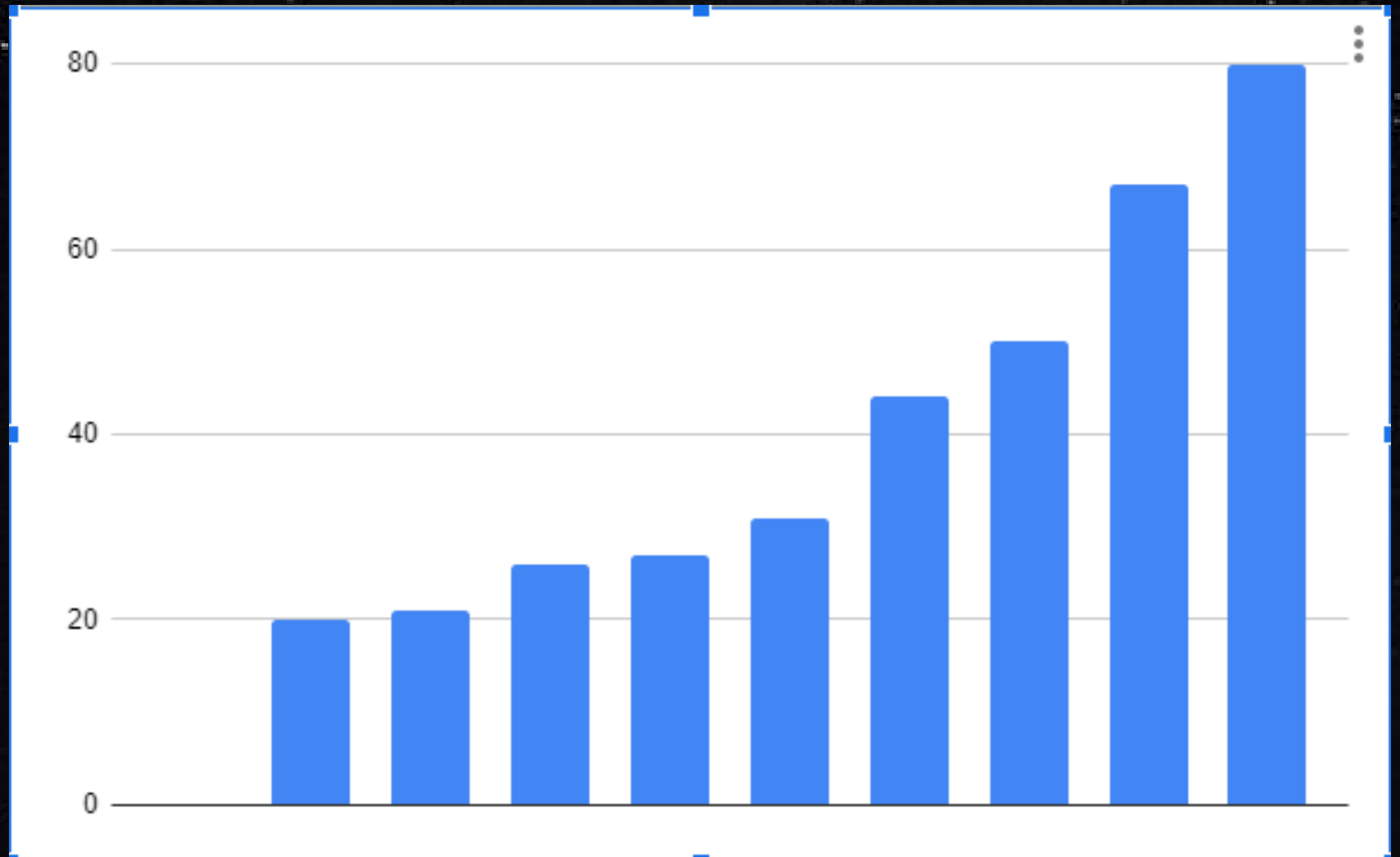
Solution?

- They may not see this

Solution?

- But see this instead

Finderchart drawing rebased to 100



Last Words

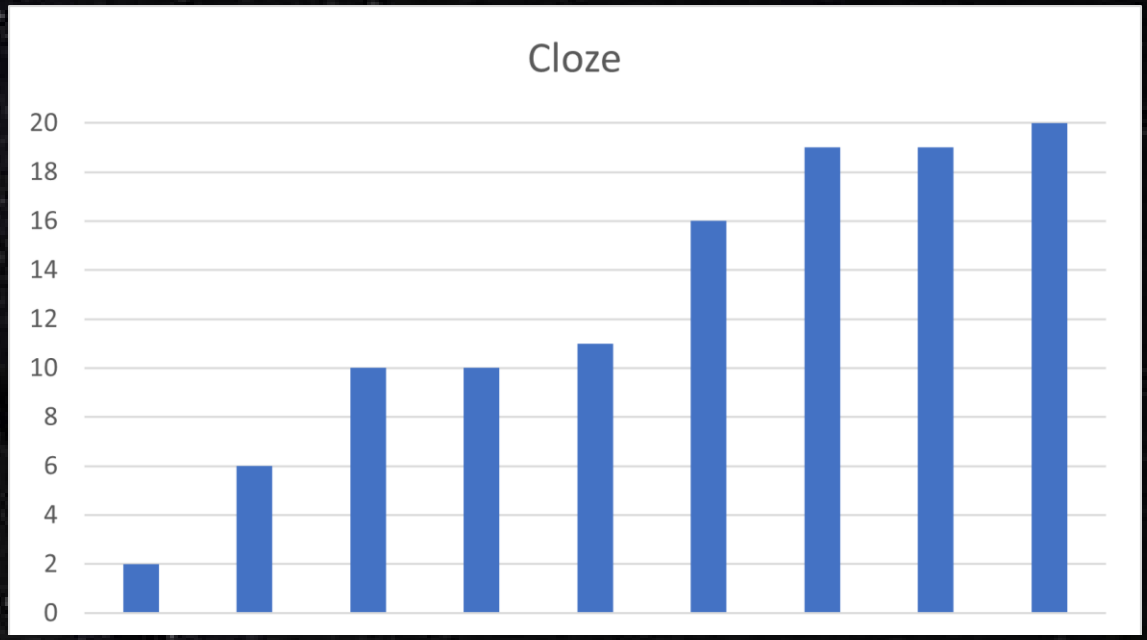
- Most of the teams labelled the start and end.
- Only one team found the object in the end.
- Only two teams used the finderscope.

Cloze Passages

Q Setter: Nicholas T and Nicholas P

Section 2: Cloze Passage

Mark Distribution:



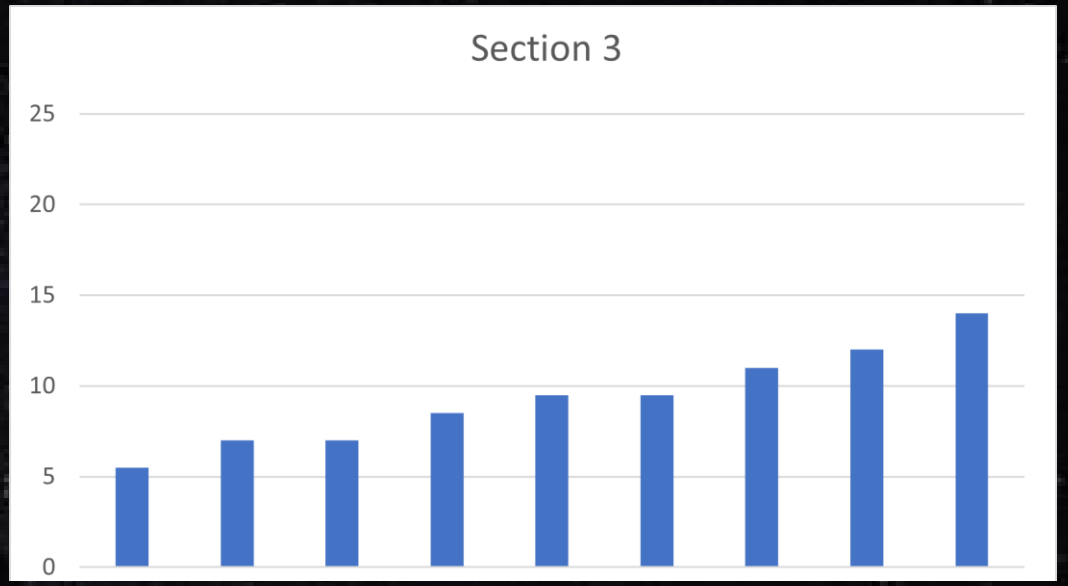
- Nothing to note in particular
- Since most blanks are interlinked, you either get it all or none
- A surprising number of you managed to get the answer for Cloze 1, K (Pacman Nebula)

OEQs (Sect 3 and 4)

Q Setter: Ken Rui

Section 3: Mount and Setup

- The Bad:
  - Highest: 14
  - Mean: 9.33
  - Poorly done
  - Many questions skipped
  - Many cried tears of blood during this section (probably)

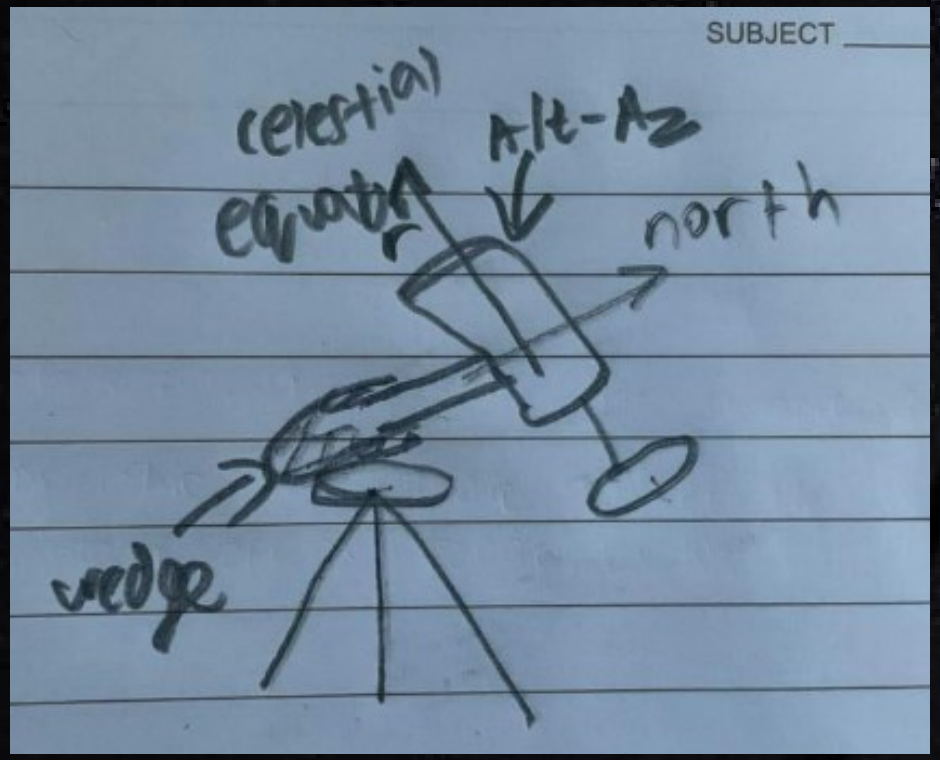


- The Good:
  - Maybe it's the QM's fault?

- The Bad (again):
  - Many of your answers demonstrate only a vague or superficial understanding of how EQ/Alt-Az mounts work
  - Literally *no math required* for this section, but yet…
  - Even the more difficult questions are intended to be solvable with clear and rigorous thinking + good reading comprehension
    - Most of y'all instead panicked upon seeing an unfamiliar question and fumbled the bag
    - Some of you got tantalizingly close to the correct answer, with some careless mistakes

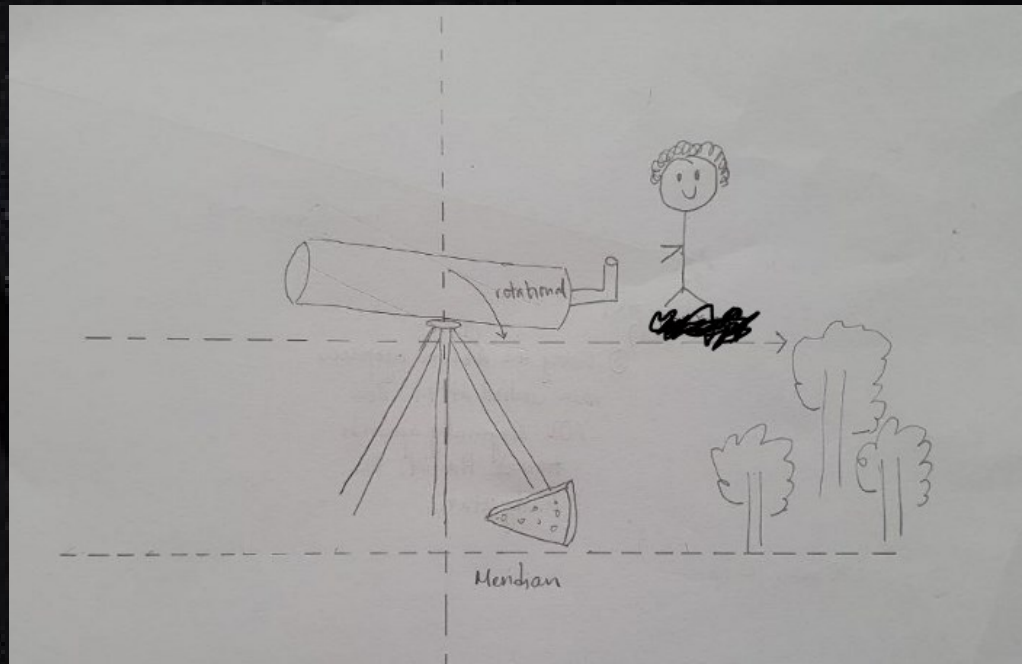
Conclusion: It's probably not the QM's fault

Almost correct answers – Q4



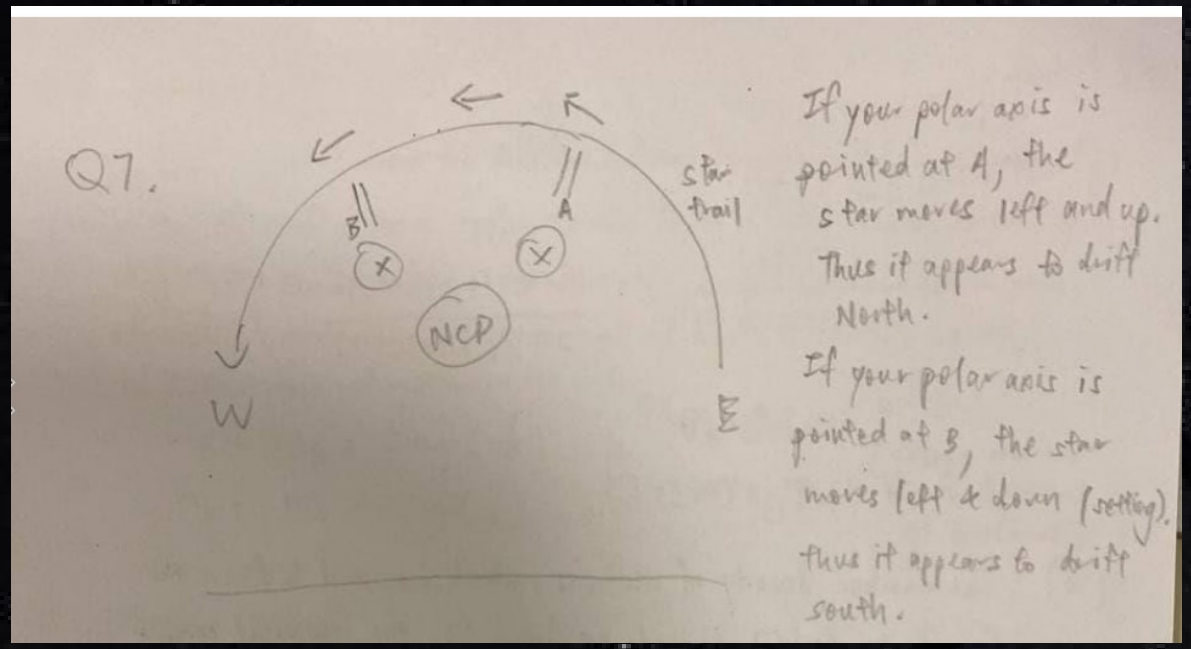
Only team that gave the correct alignment of azimuth axis to NCP

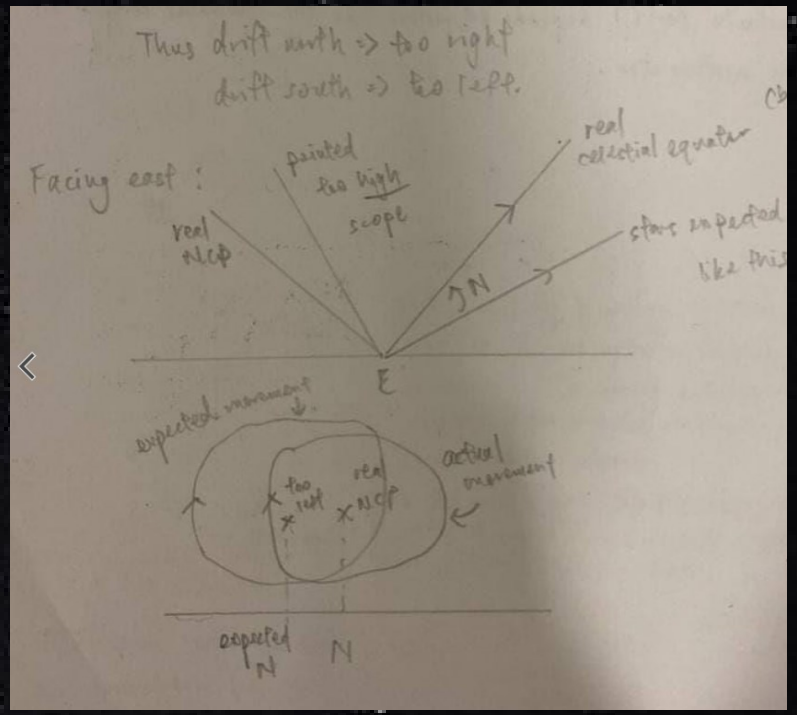
Somehow also one out of the two teams who drew the wrong wedge position



The one other team btw →
Please don't ever try this with your club telescope

Almost correct answers – Q7

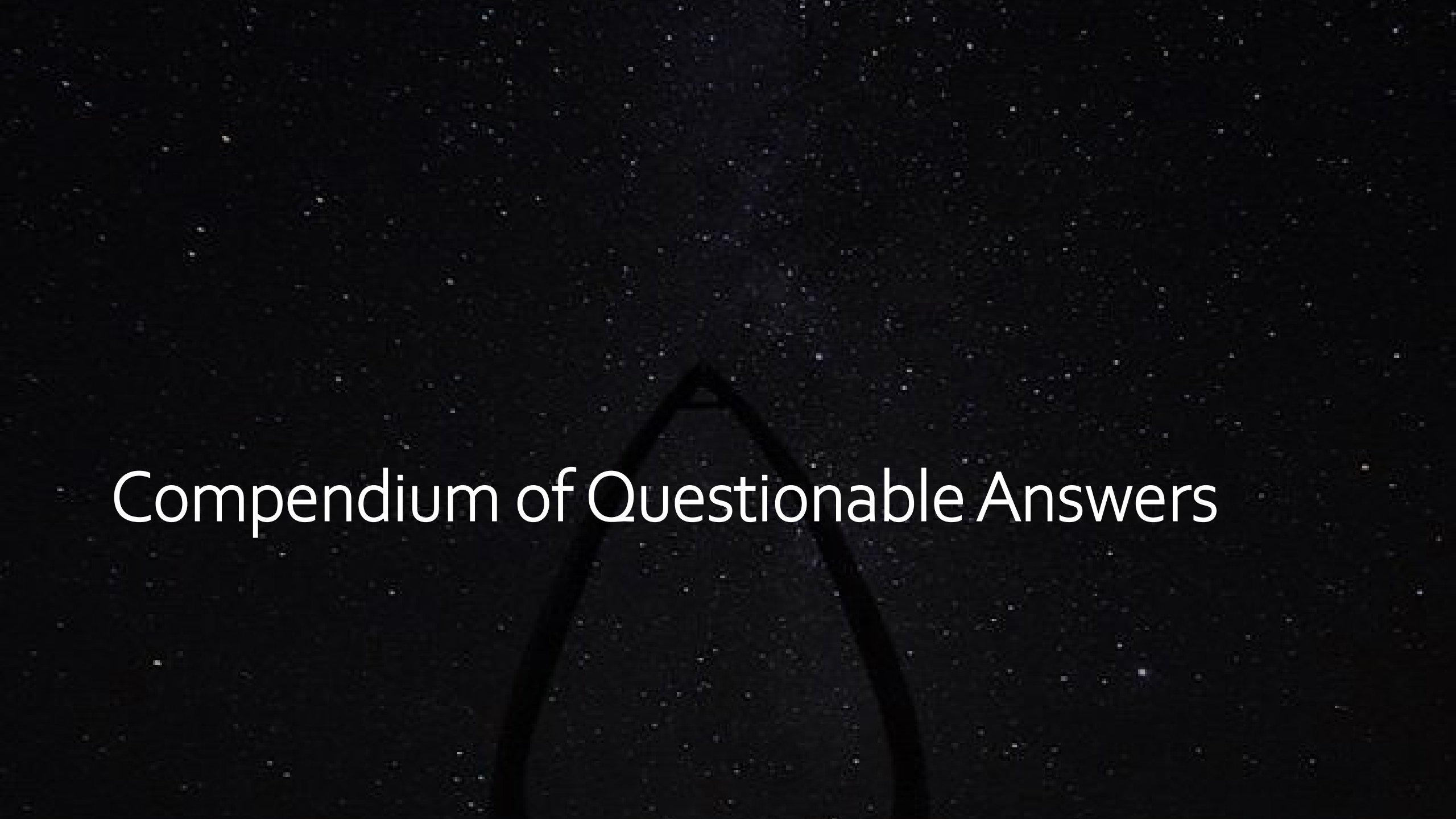




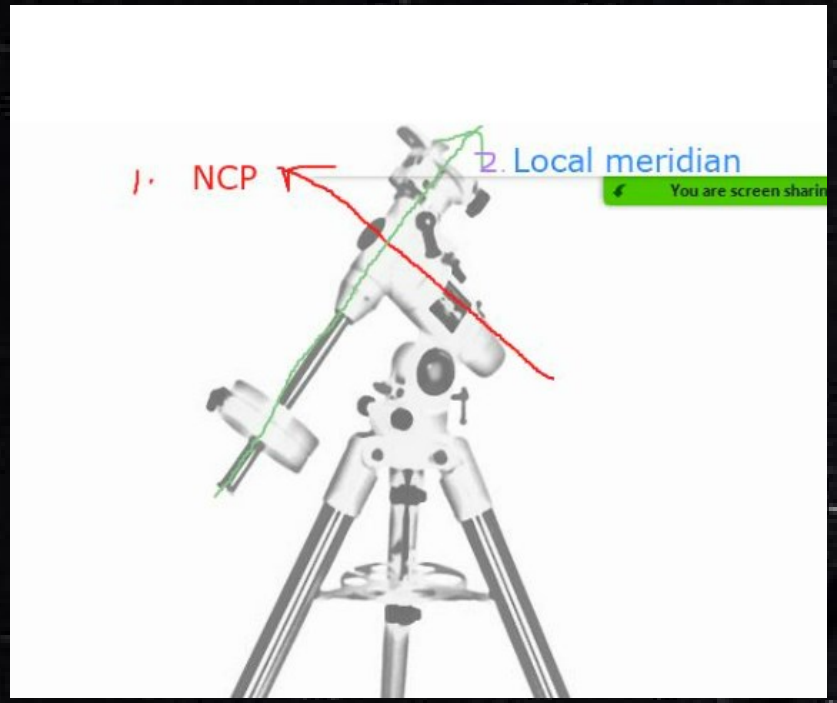
Correct diagram and reasoning
But wrong definition of North and South used

Think! Is up == north and down == south? Think!

Also the definition was literally included in the question!



Compendium of Questionable Answers



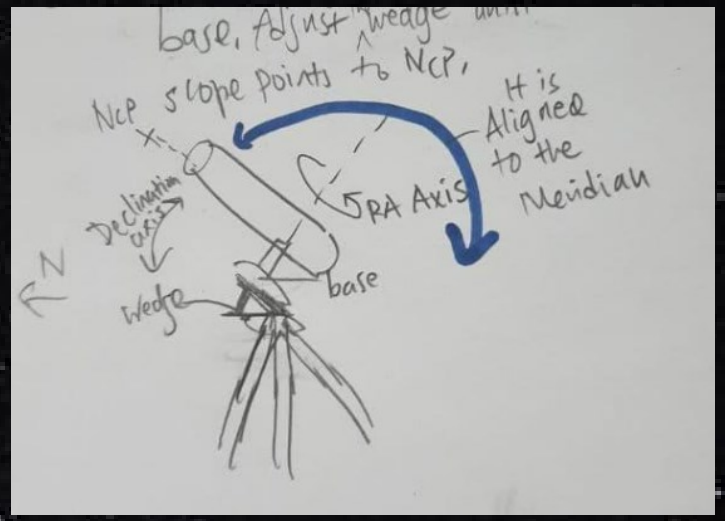
Dec Axis aligned to Meridian???

What happens when you rotate the RA axis? Does the Meridian rotate as well?

Singapore is located only a few degrees above the equator so North pole is located only a few deg above horizon. It is not feasbile for the wedge to provide such a small angle of about 1 to 2 deg to elevate the base of the alt-az mount.

Singapore is close to the equator and hence the north celestial pole lies close to the horizon. An equatorial wedge is hence not required to ensure that the mount is aligned to the North Celestial Pole.

Q5. Singapore is at the equator so no need to account for latitude differences, hence we do not need an equatorial-azimuth mount adjuster.

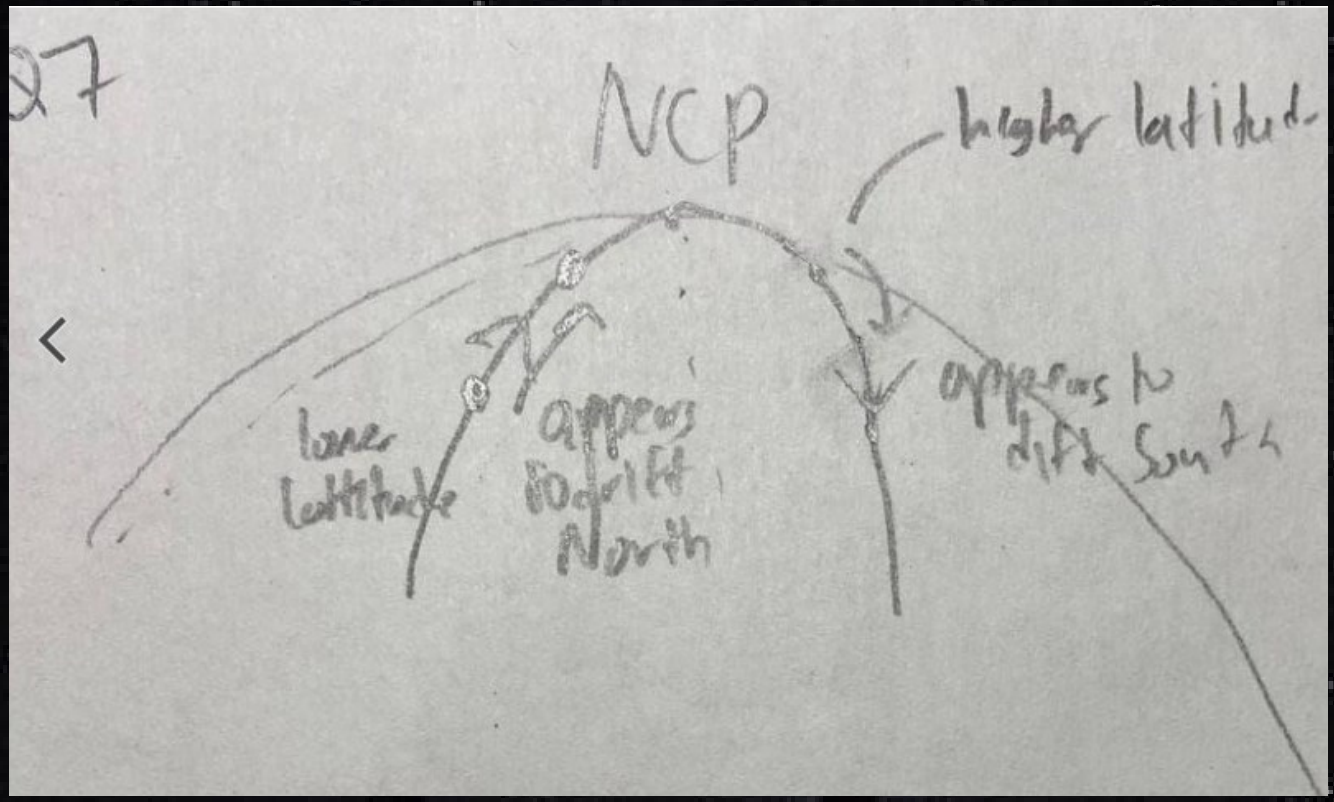


Think about what you are actually claiming!

Is an EQ mount at zero deg latitude identical to an Alt Azimuth mount??

Do they both rotate the same way in this position??

What about this position?



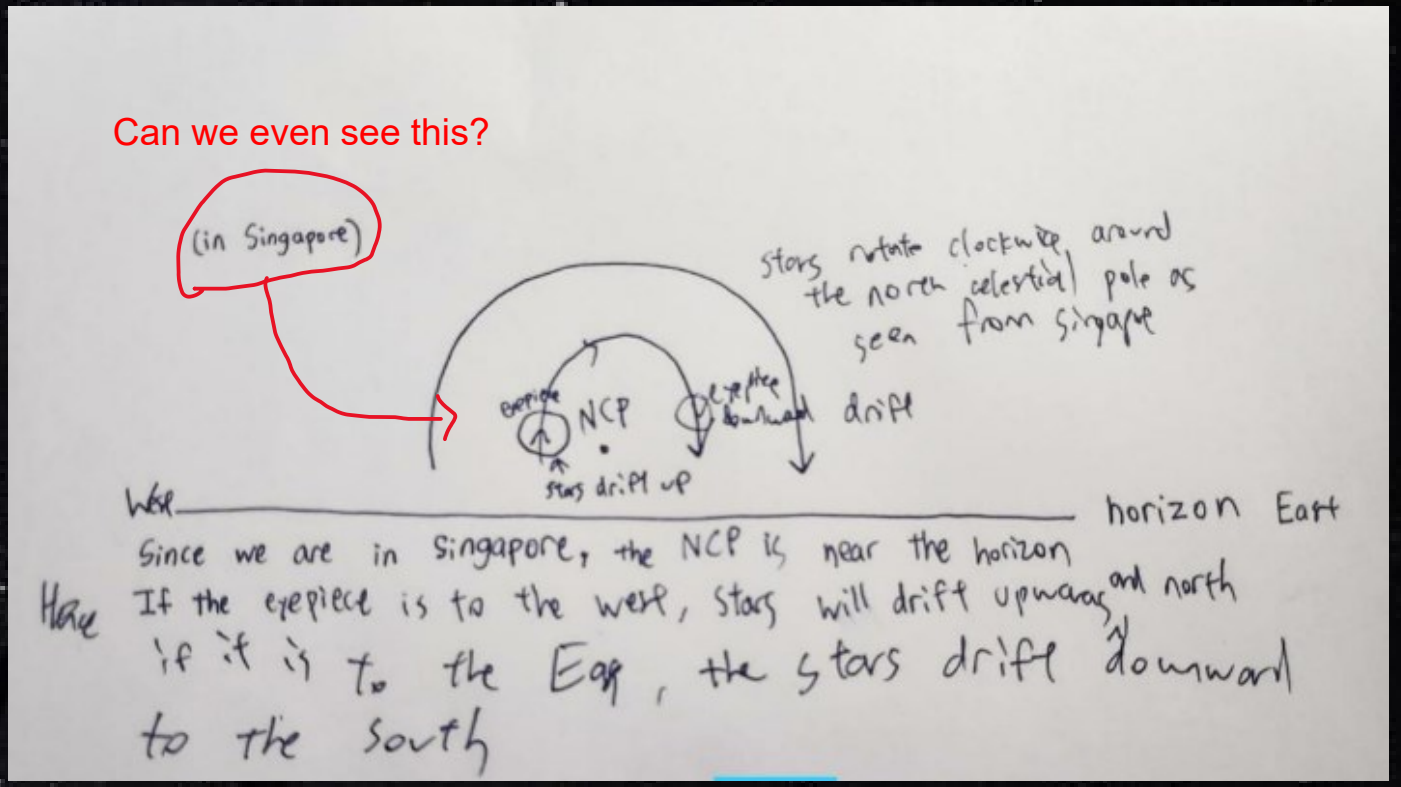
- What do you mean?

  Do stars move towards and then away from the North Celestial Pole???

Many of your answers to Q7 look like this

Did you even read the passage?

In the first place, the point of drift alignment is to get around not being able to see Polaris from Singapore...



(1) After doing a rough alignment of your mount, turn on the clock drive of the mount and point your telescope towards a star in the northern celestial hemisphere, near the local meridian. If the star drifts north in your eyepiece FOV over time, the mount is pointed _____ of the NCP, and if the star drifts south the mount is pointed _____ of the NCP.

QN 9: field rotation is caused when an equatorial mount is not perfectly aligned with Polaris.

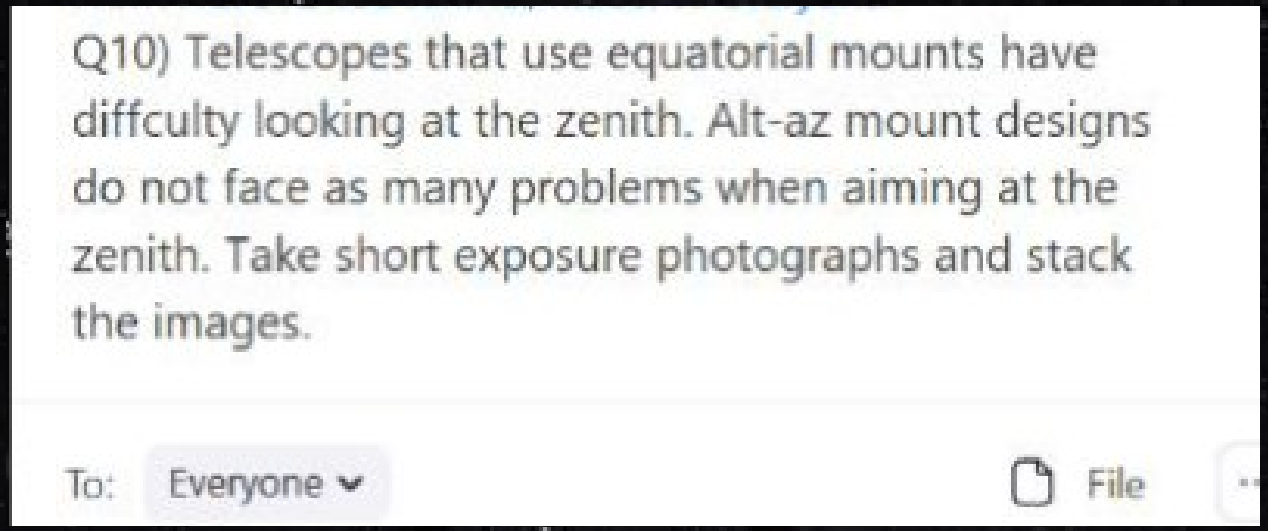
Again, did you read the question?

Q9. In long-exposure deep sky astrophotography, Equatorial mounts are often preferred over Alt-Az designs as the effects of field rotation are minimized. Explain what causes field rotation and how it affects long-exposure astrophotography. [2m]

~~Q#5: field rotation~~ is caused when an equatorial mount is not perfectly aligned with Polaris.

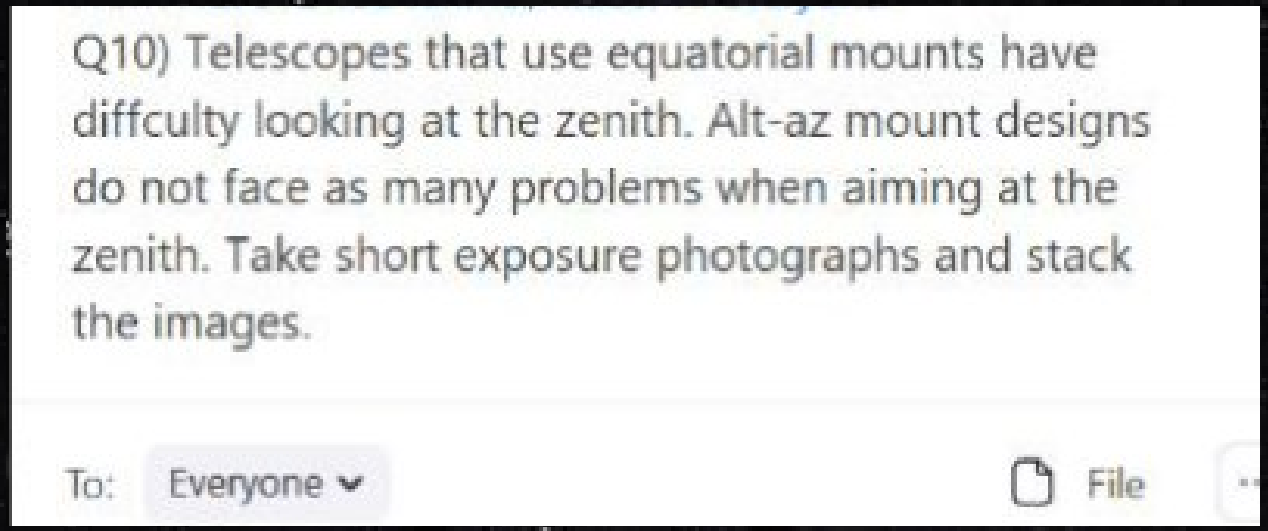
Star drift in eyepiece

By chance, this is actually describing how drift alignment works



1. What's the point of spending up to a billion dollars building a giant observatory only to use short-exposure photographs and stacking?

*cries in wasted public money



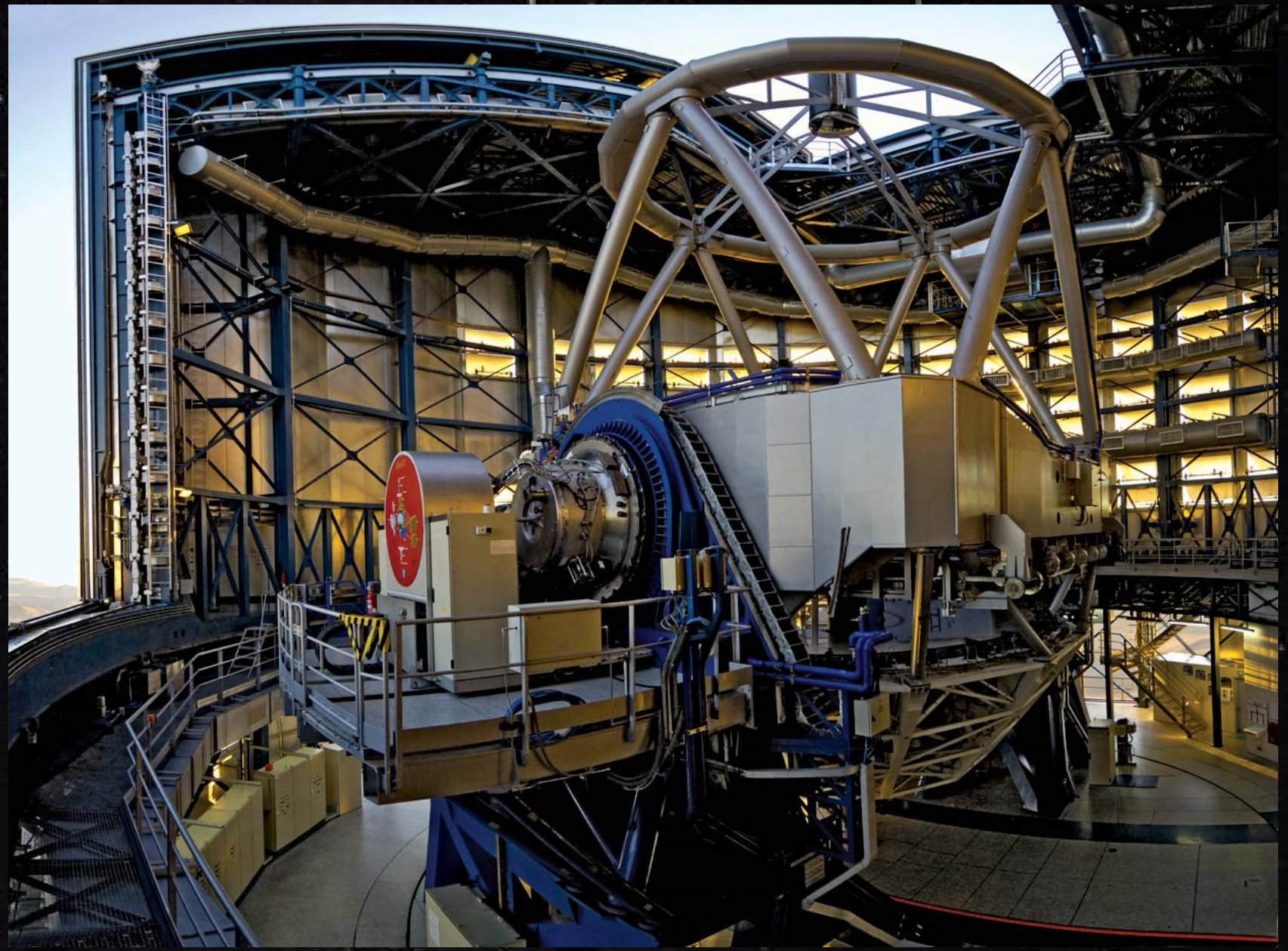
2. Alt-azimuth mounts are the one with issues photographing the zenith (that is when the effects of field rotation is the largest)!

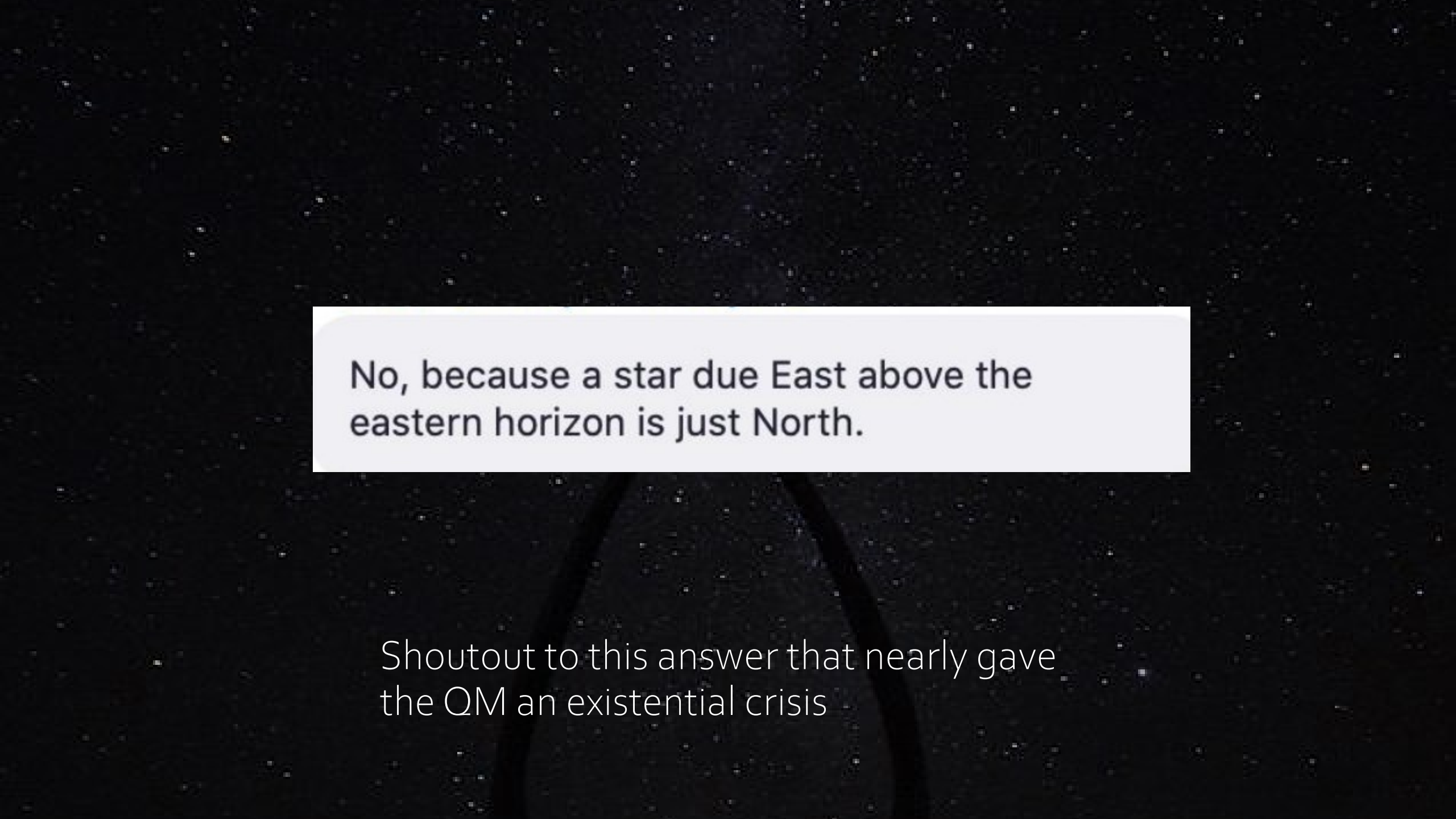
Eq mounts face a different problem, having to perform a meridian flip when tracking objects across the meridian. Does this sound familiar to you?

Btw this is the Very Large Telescope (VLT)

Now, why do you think this is not mounted on equatorial?

There is no need to overthink your answer!

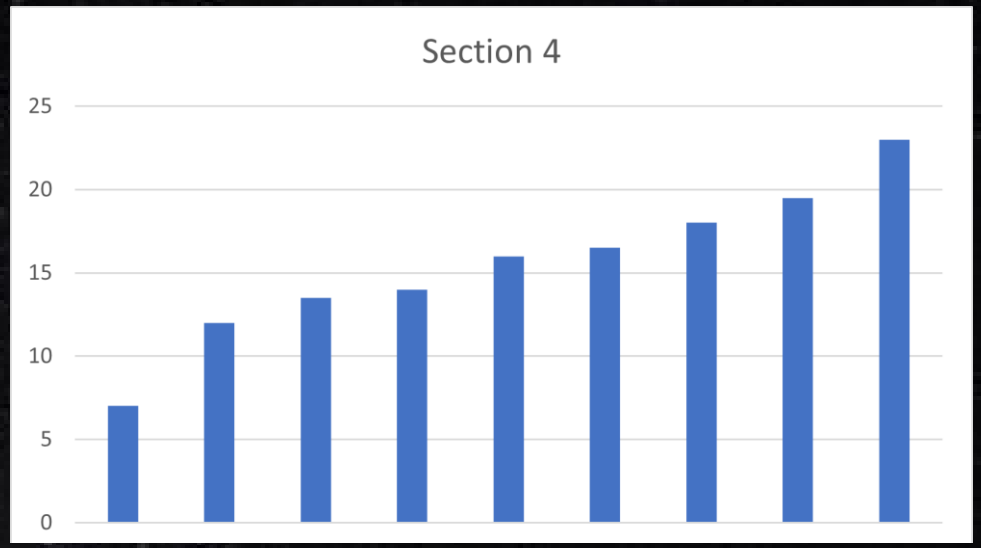




Shoutout to this answer that nearly gave the QM an existential crisis

Section 4: An Unfamiliar Ceiling

- The Good:
  - Highest: 23
  - Mean: 15.5
  - Obviously much better done than the previous section
  - The best team was very close to getting full marks



Section 4: An Unfamiliar Ceiling

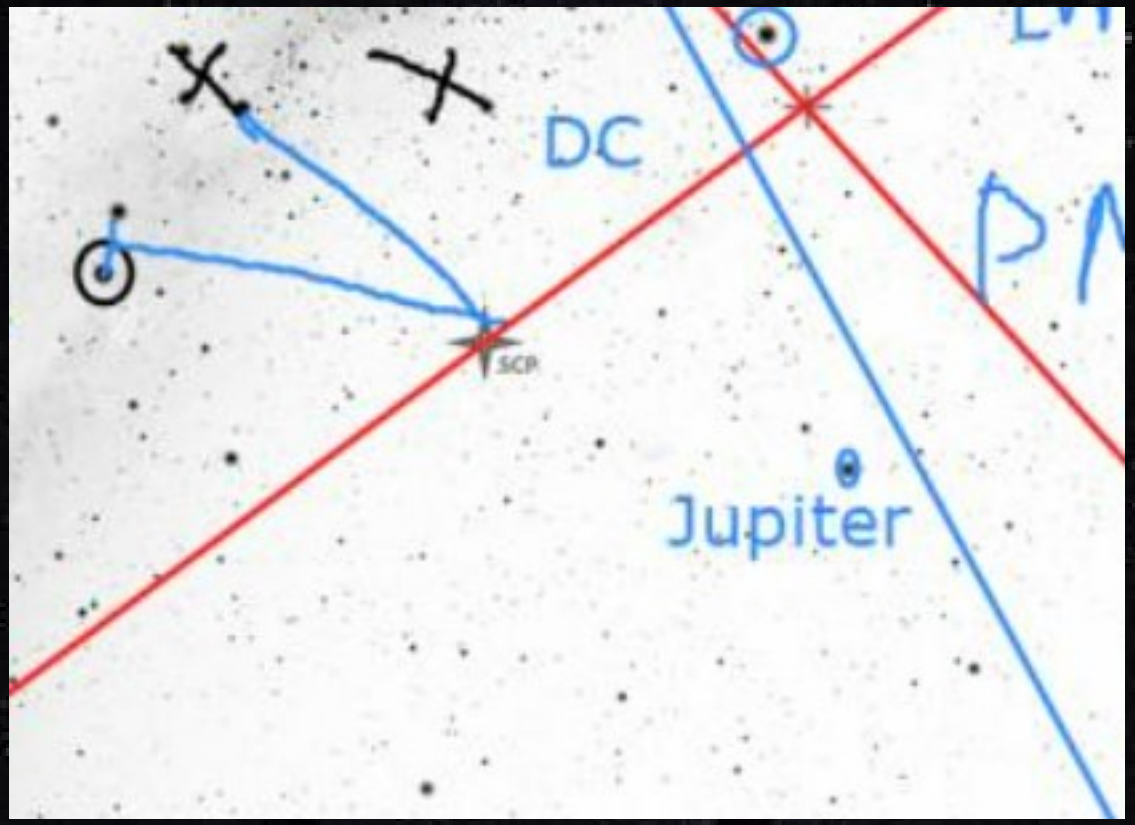
- The Bad (of course):
  - Most of the marks are giveaway marks
  - Many failed the giveaway marks
  - Many questionable answers which exposed a lack of clear conceptual understanding

A recap of Observational Astronomy

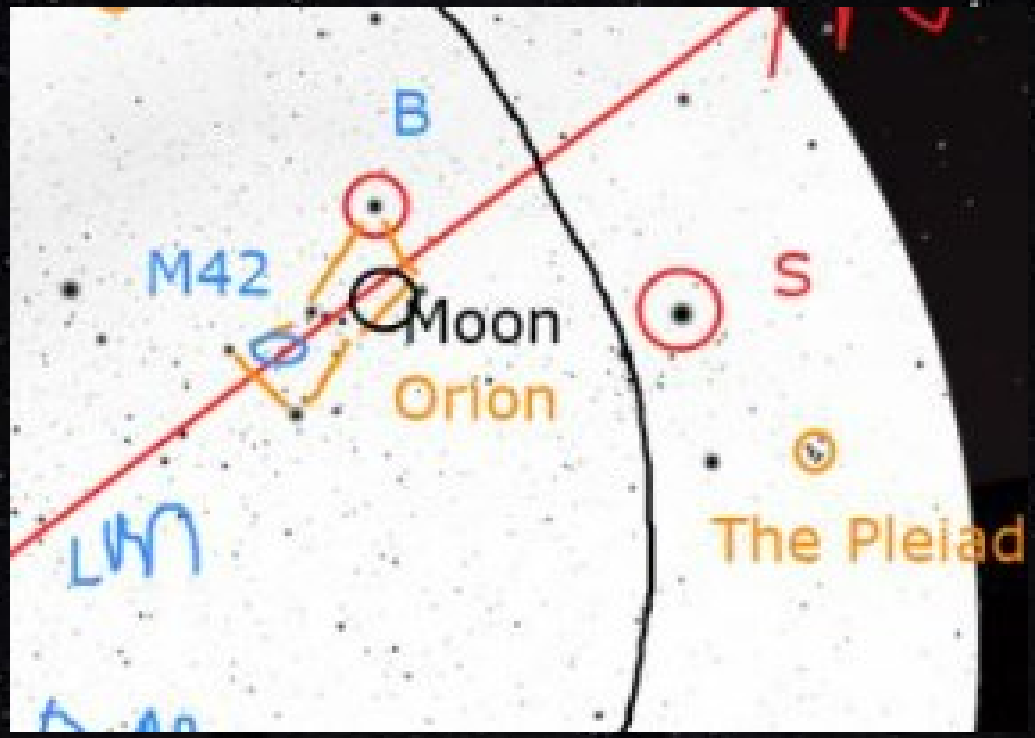
1. Knowledge of the constellations, asterisms, Deep Sky Objects (DSOs) etc.
2. Knowledge of solar, lunar and planetary movements, how the night sky changes with location, seasons and astronomical timekeeping

Of which, the latter is the very core of various astronomical traditions from various cultures stretching all the way back to Antiquity

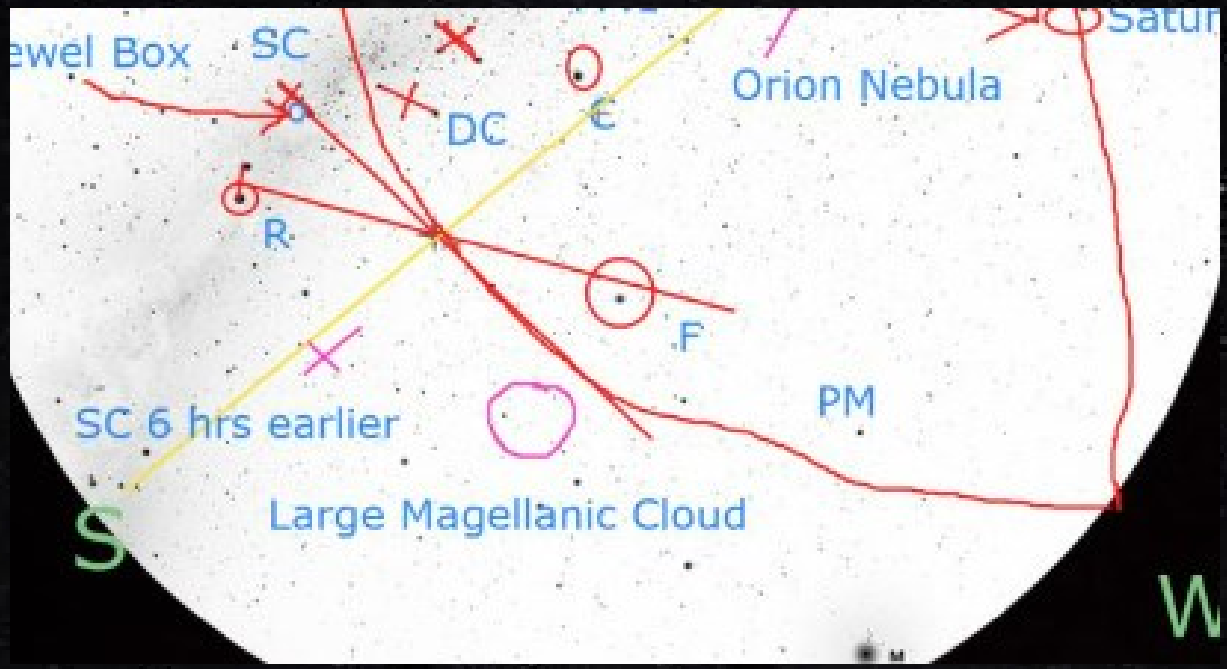
The latter is also what many AC participants seemed to have ignored in their studies and preparations.



Jupiter is ejected out of the plane of the solar system, and ends up near the South Celestial Pole

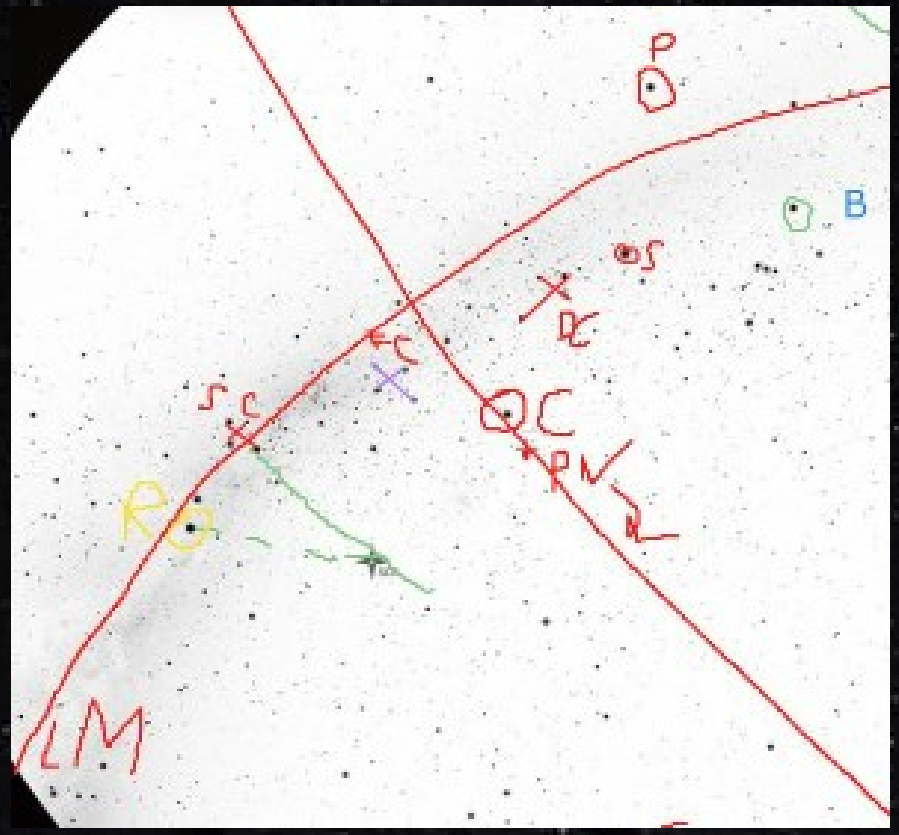


Sanity Check: When is Sirius ever near the Pleiades?

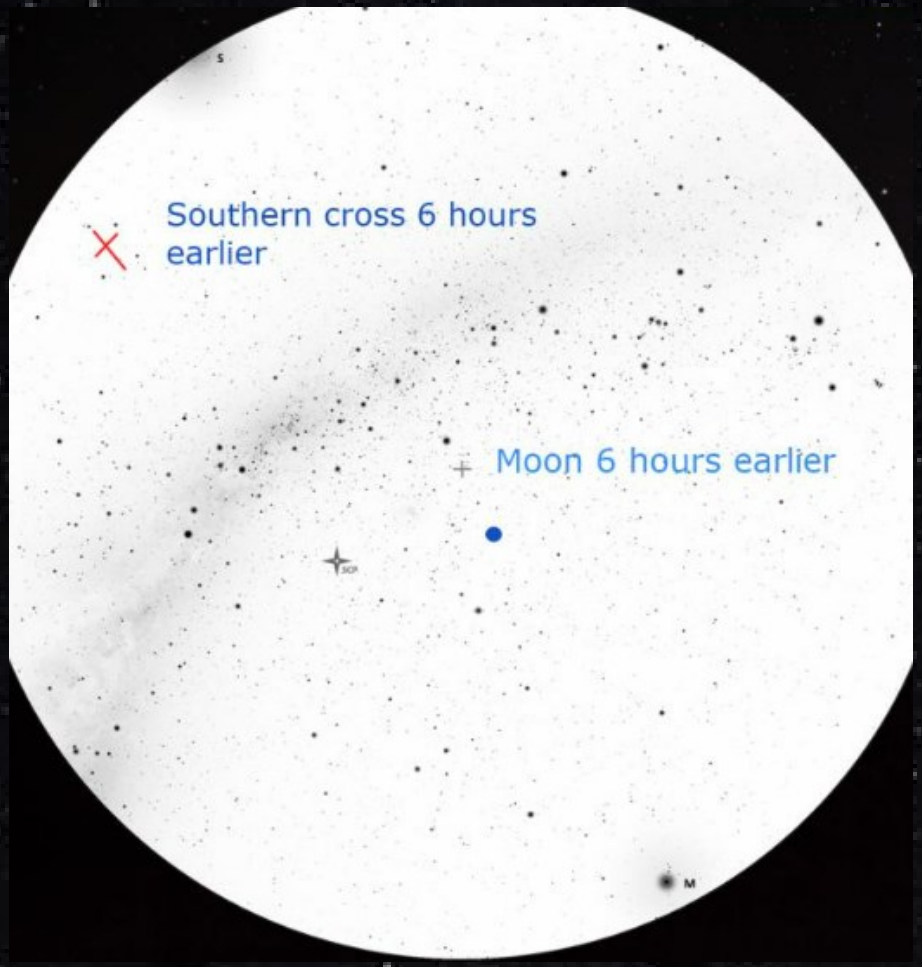


Is the Prime Vertical a curve?

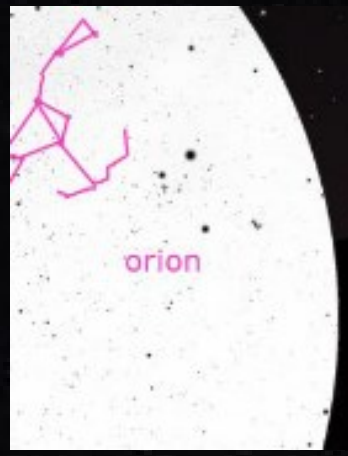
P.S. This is a Right-Ascension Line



Does the Local Meridian (LM) follow the Milky Way



Even though this is the Southern Hemisphere, their minds are still stuck in the Equator



Q9. State a constellation in its lower culmination. Type in the box provided below. [1m]

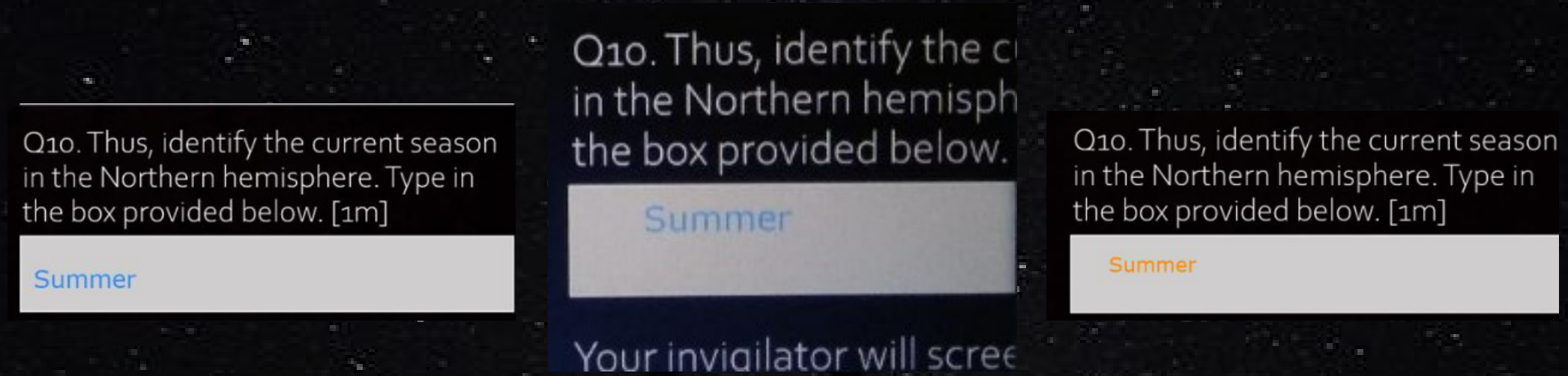
Orion

Q9. State a constellation in its lower culmination. Type in the box provided below. [1m]

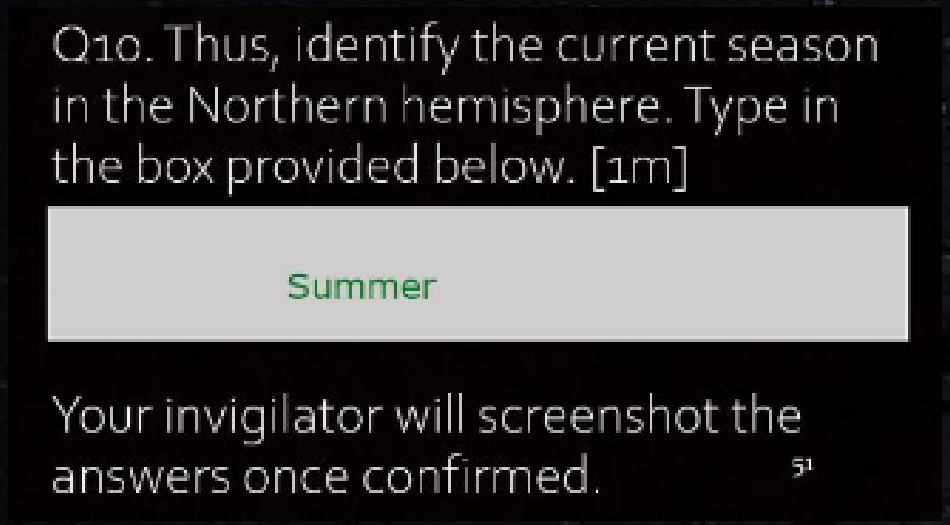
Gemini

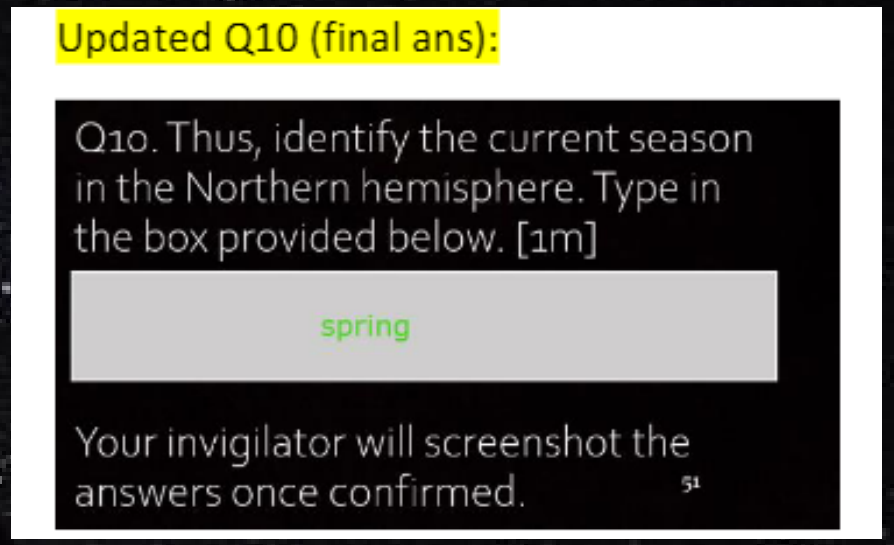
Your thought process: When an object is in its lower culmination, it is crossing the meridian overhead in the Southern Hemisphere

Is this correct?? Do the North and South Hemispheres face opposite sides of the sky??



A good number of you answered Summer for this question





One team answered summer, and later changed to spring (which is still wrong)

Taken together, your answers imply this thought process:

1. Currently winter sky is overhead in the southern hemisphere
2. Therefore, summer sky is overhead in northern hemisphere
3. Therefore, it is summer

Issue 1: It is current sunrise at roughly 6 AM LST (explains the answer change to spring)
Issue 2: The sun is rising near due east so it must be near the Equinoxes
Issue 3: Again, do the northern and southern hemispheres face opposite sides of the sky (in a single night)?

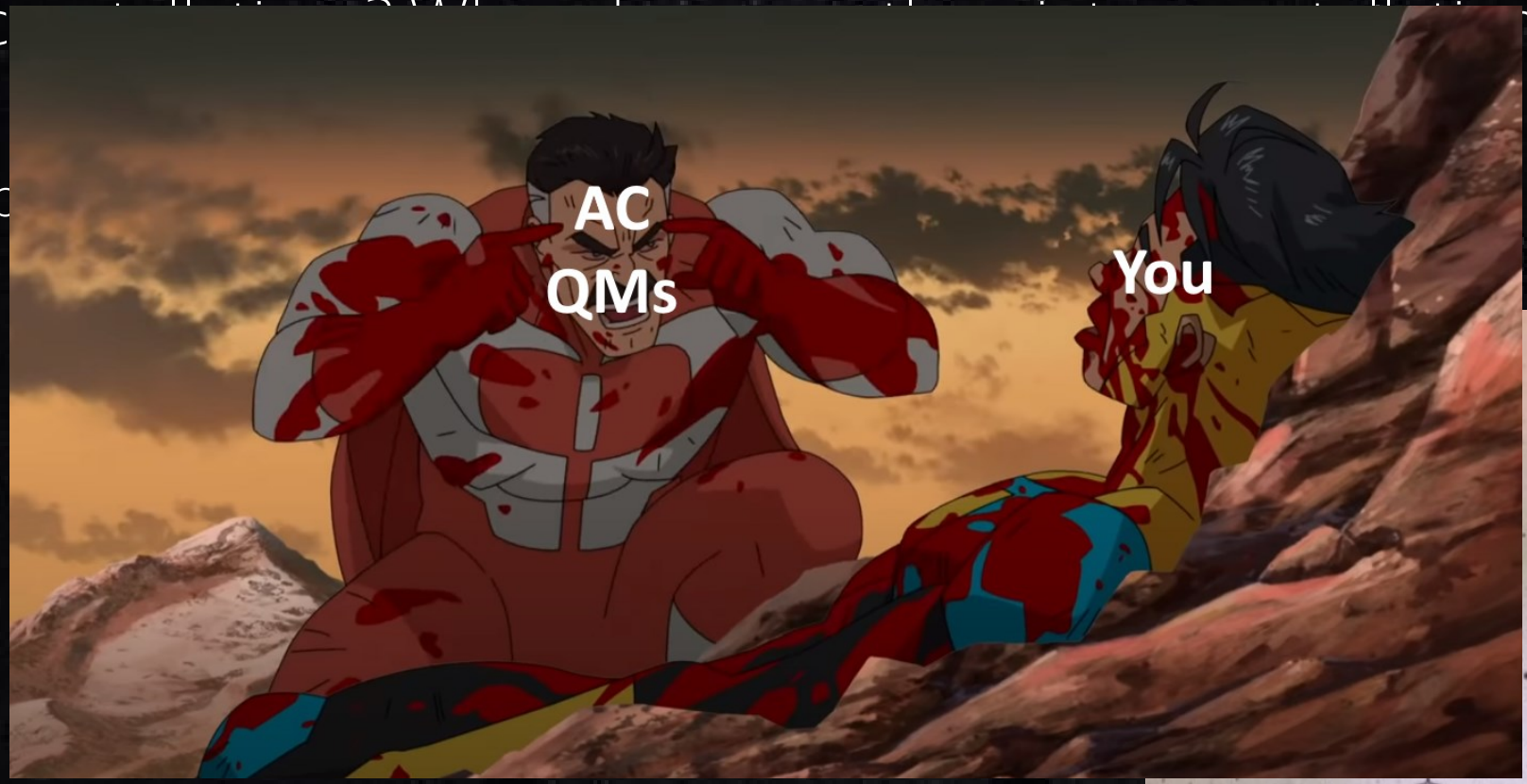
Sanity Check: We are near the equator in Singapore. When do we see the summer constellations? When do we see the winter constellations?

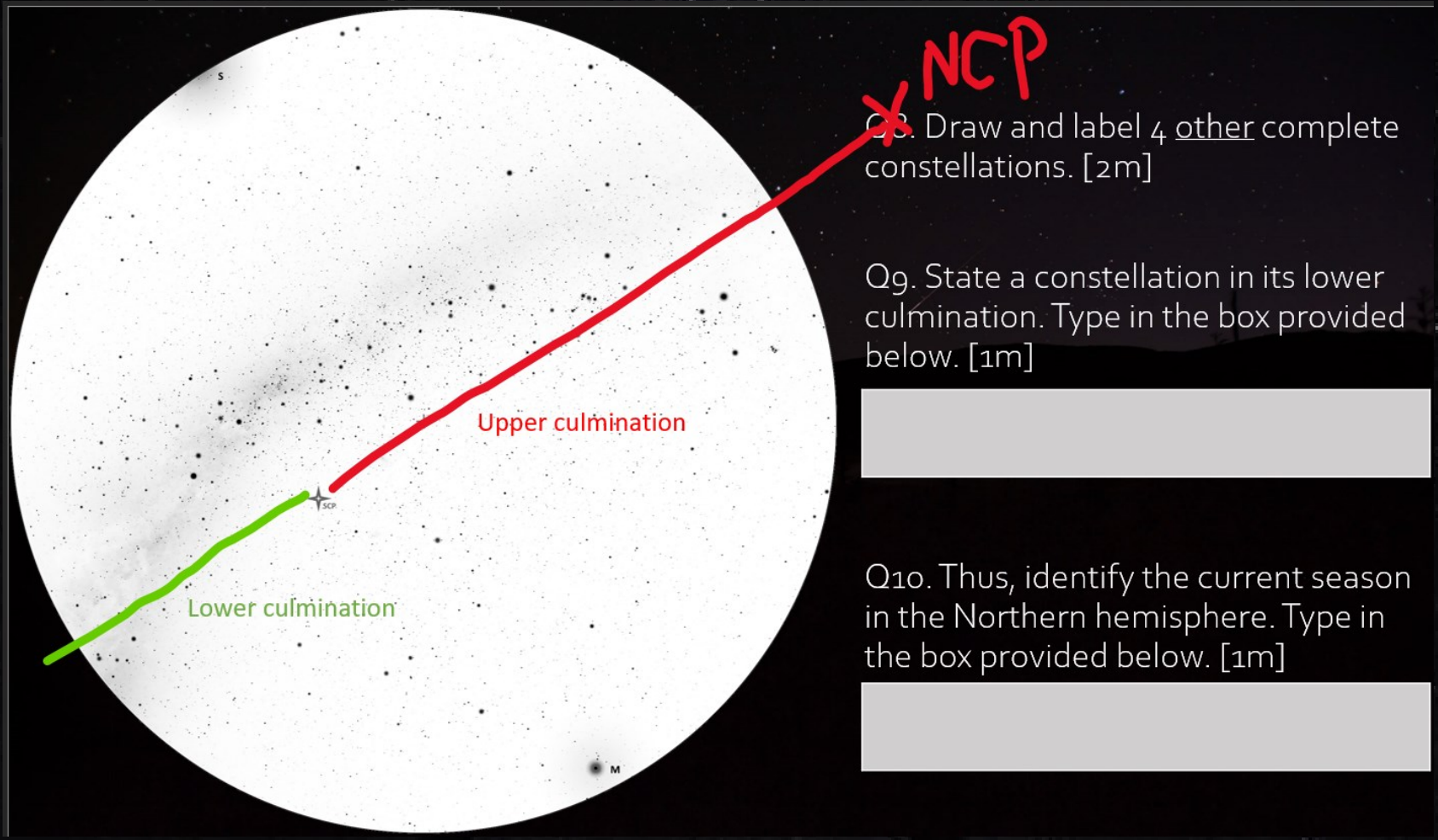
Do we see both summer and winter constellations at the same time? (Since we are in the middle)

I.e., do we see this:

Sanity Check: We are near the equator in Singapore. When do we see the summer c ns?

Do we see b we are in the middle)





Q8. Draw and label 4 other complete constellations. [2m]

Q9. State a constellation in its lower culmination. Type in the box provided below. [1m]

Q10. Thus, identify the current season in the Northern hemisphere. Type in the box provided below. [1m]

This is how the sky actually works

We are all looking at the same sky, tilted at different angles

Q14. Explain your answer. Type in the box provided. [1m]

Assuming that saturn lies on the local meridian during opposition, since the Earth rotates from west to east, saturn is likely to be leaving opposition since it is past the meridian

Q14. Explain your answer. Type in t box provided. [1m]

Saturn is approaching its lower culmination while the Sun is just rising

Some teams conflated opposition with Upper Culmination/Lower Culmination/ Anything to do with the daily rotation of the Earth

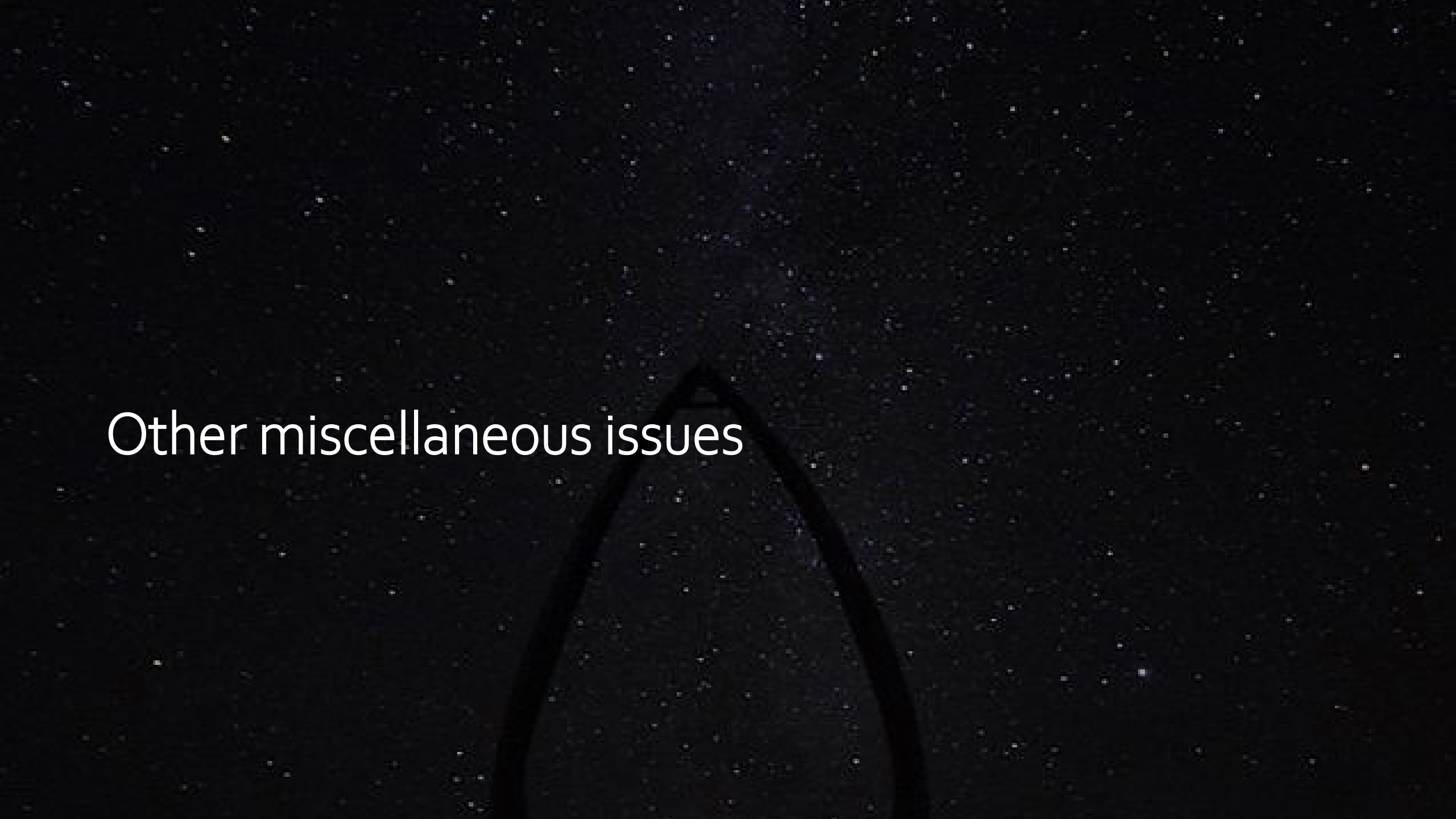
Sanity Check: Is opposition a particular time of the night, or a range of dates?

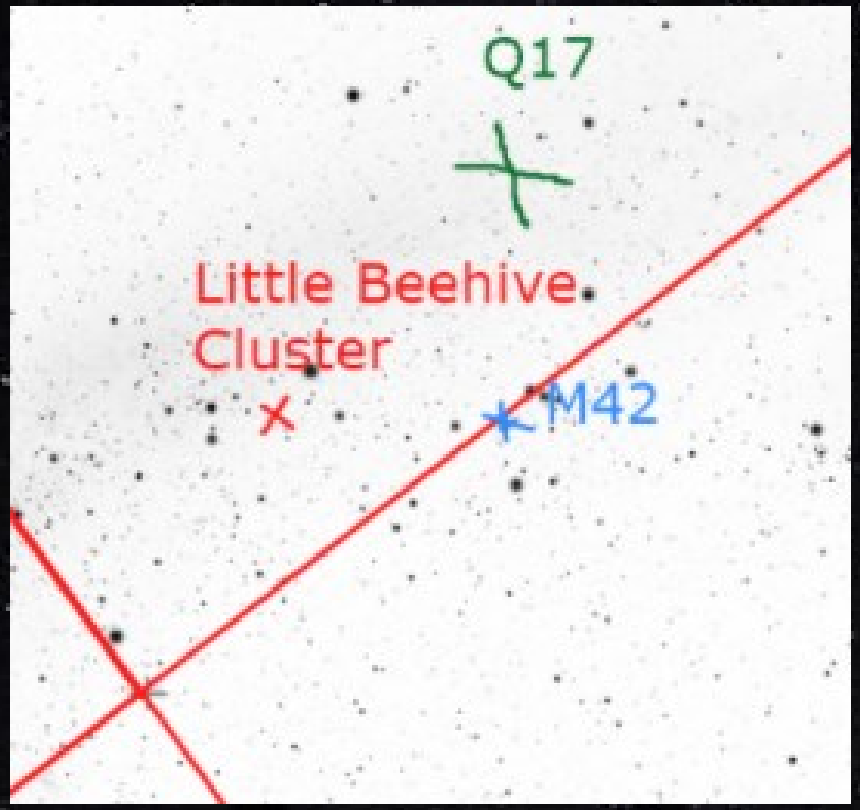
Q14. Explain your answer. Type in the box provided. [1m]

In the winter season, as earth orbits around the sun, the orbit of saturn starts catching up with that of earth and is approaching the opposition

An obvious and rather poor attempt at smoking

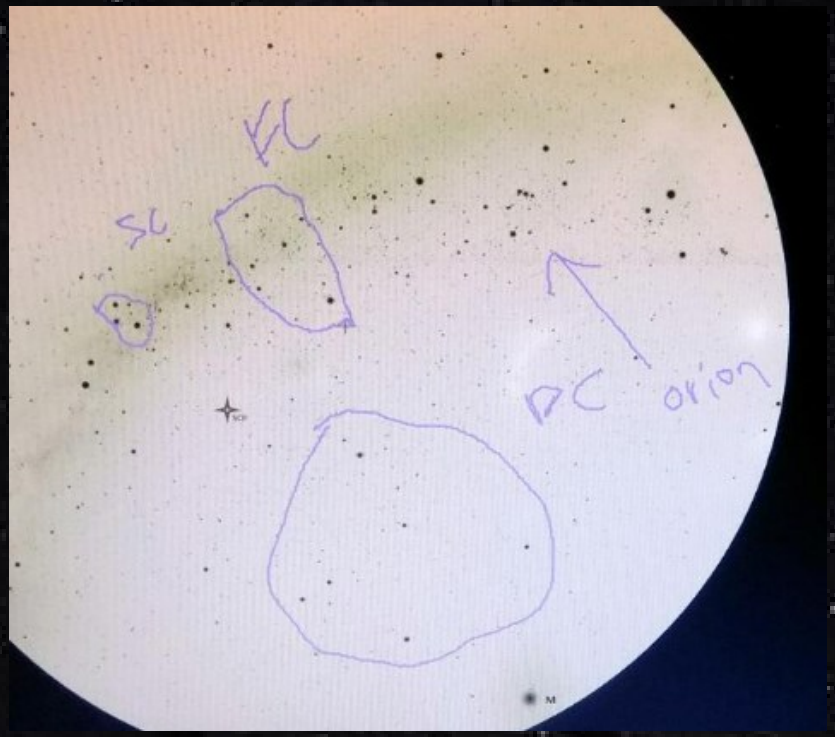
Sanity Check: Is Saturn always in opposition in winter? What happens when Saturn is in Scorpius? Do we see a rare once-in-a-century winter Scorpius?


Other miscellaneous issues



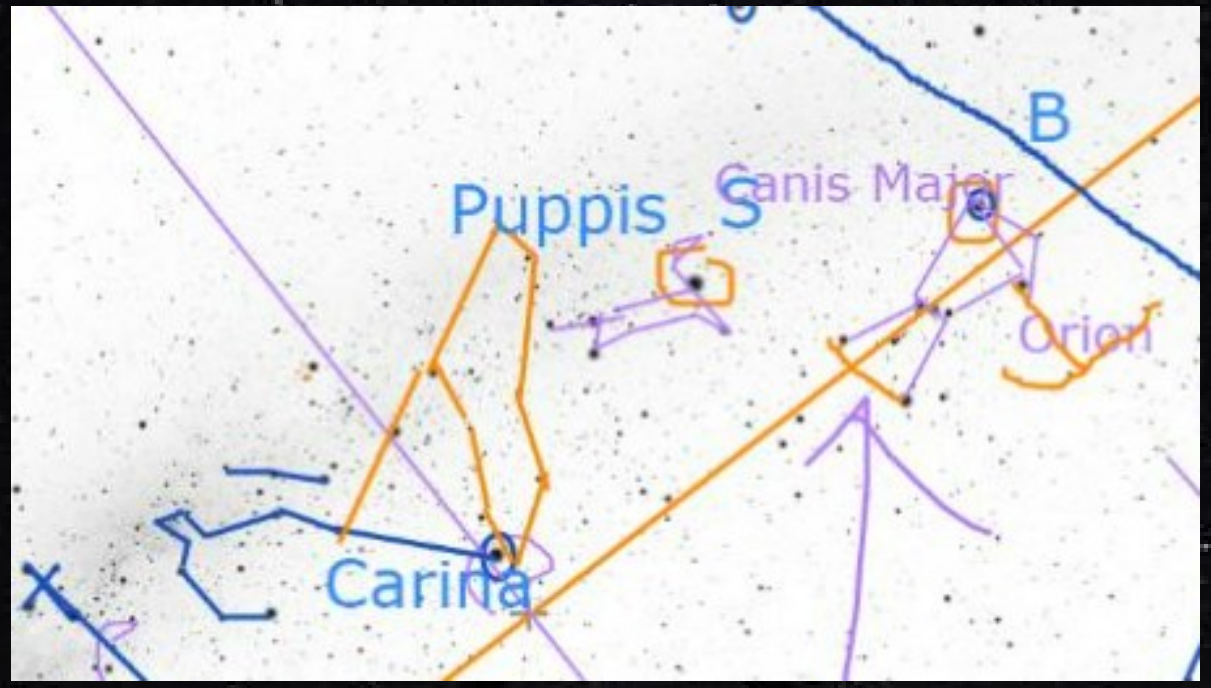
Please don’t use obscure names and confusing names for DSOs (just write M41)

You gain nothing from trying to show off here



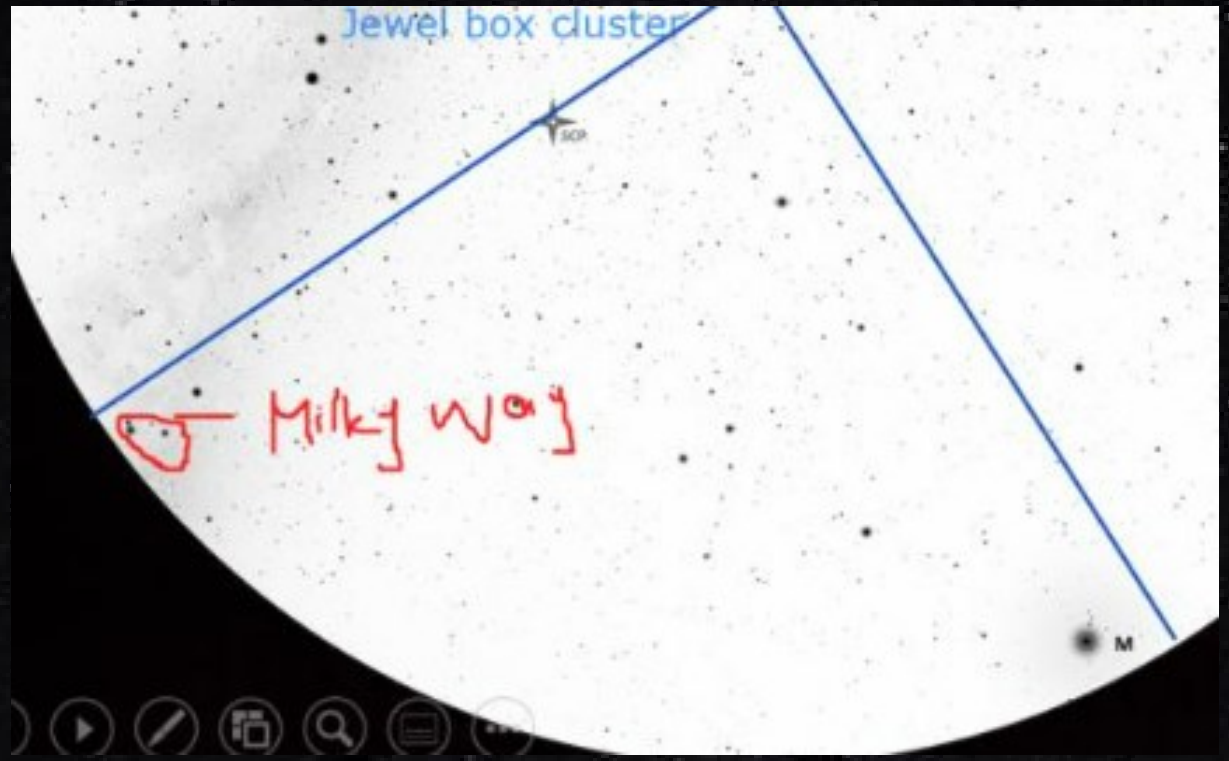
Inability to read and follow instructions

(Circle the constellation or draw the constellation?)

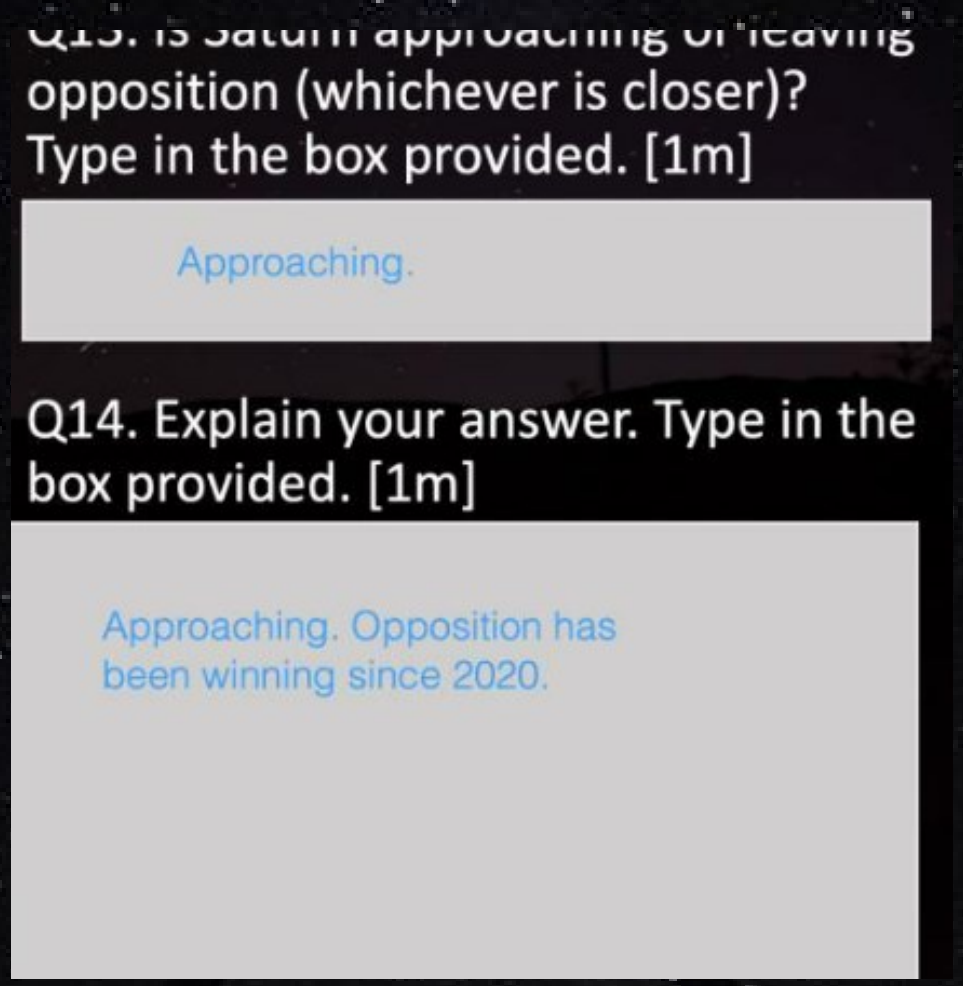


Don’t geh kiang and try to show off: It may backfire on you

This team chose to draw 5 instead of 4 constellations, and was later penalized for including stars from Vela and Carina in Puppis

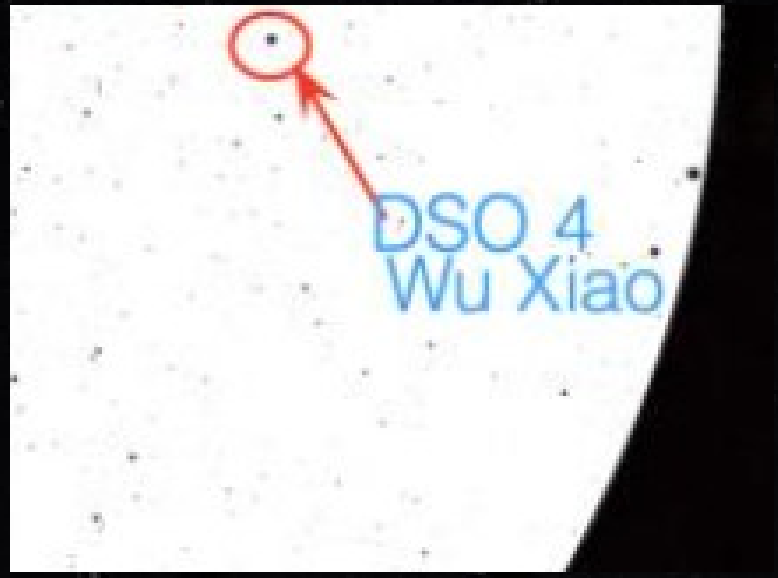


No.



Do avoid making political jokes.

(later pofma)



Please don’t bully your poor team admin.

Lastly,

Q14. Explain your answer. Type in the box provided. [1m]

Since the position of saturn is quite close to sun (relatively), the planet is considered to be leaving opposition as saturn will be visible during local midnight when it is in opposition (I think) (We tikam)

It’s ok, everybody in AC also tikam one


玩完。