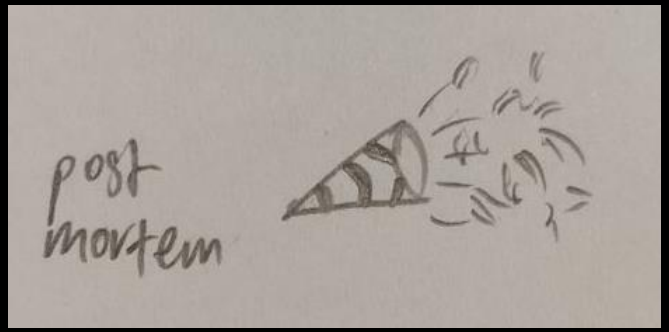


AC2023 Post Mortem

Presented by AC2023 QMs

“Its not about how we make mistakes, but how we correct them.” -- KY

1. Introductions

The AC2023 Family

AC committee

Chairman: Chong Ka Shing (NTUAS)

Deputy Chairman: Yong Fu Hsien (NUSAS)

NUSAS Vice President: Wang Mingchuan

AC QM Community

Head Question Master: Janani Ramachandran (NUSAS)

Deputy Head Question Master: Fredrik Hanson (NTUAS)

Department Heads

Publicity: Nicholas Tan

Head of Administration: Mohamad Hirwan

Deputy Head of Admin: Celeste Ang

Head of Logistics: Troy Tim

Head of Finance: Muhammad Tawakul

AC QM Community

OIC Project: Nicholas Phung-Zhang

OIC Observation: Wang Mingchuan

OIC Teams Round: Fong Ken Rui

OIC Individual Round: Fredrik Hanson

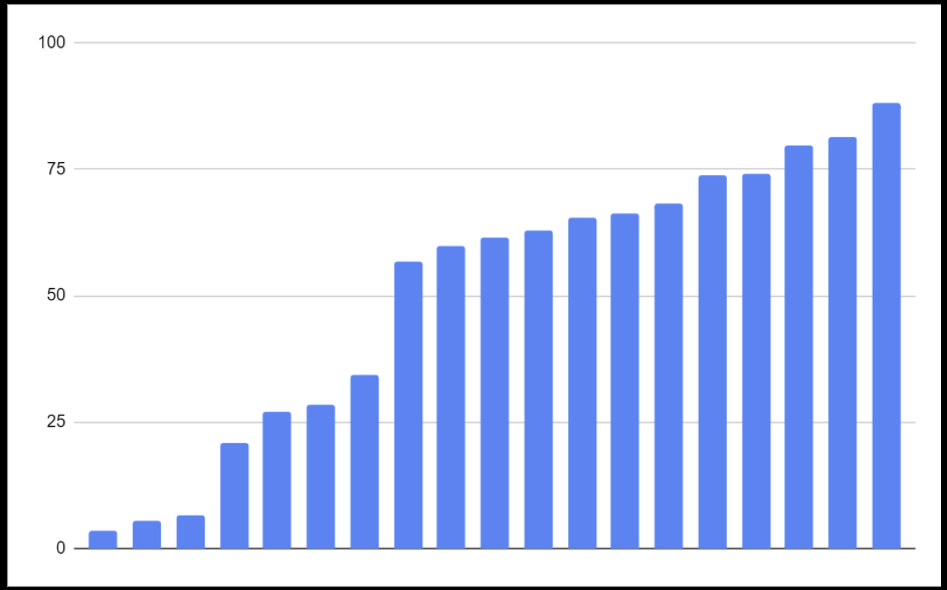
OIC Finals: Trakantannarong (Golf)

QMs: Lim Kia Yee, Wan Si Chen, Lim Tse Xiong Brendan, Jerry Qu, Lew Choon Hean, Tham Kai Wen, Benjamin Luo

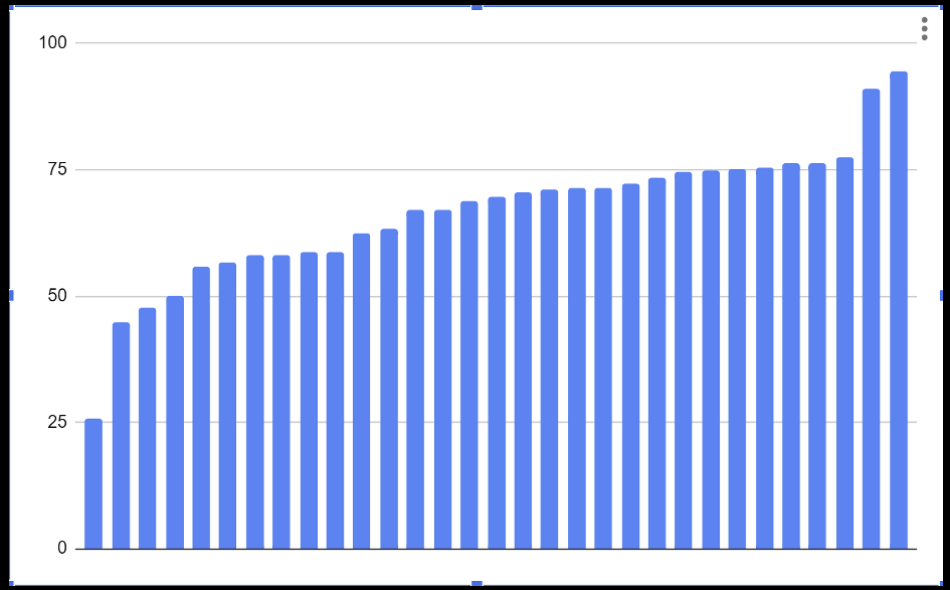
AND ALL THE QUESTION MASTERS !!

2. Project Round

Junior Distribution



Senior Distribution



Things to note

Citations:

People did not submit citations.

Late:

Quite a few. Teams have been penalized accordingly

Accuracy:

Please make sure that you know the topic at hand and not start smoking.

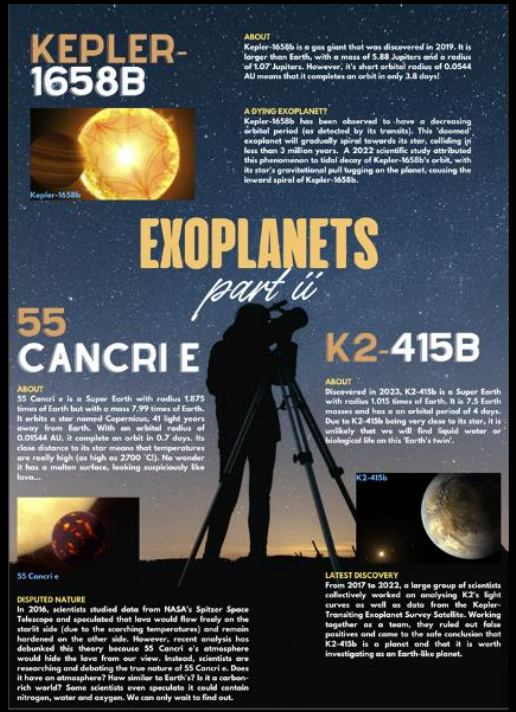
Other Issues:

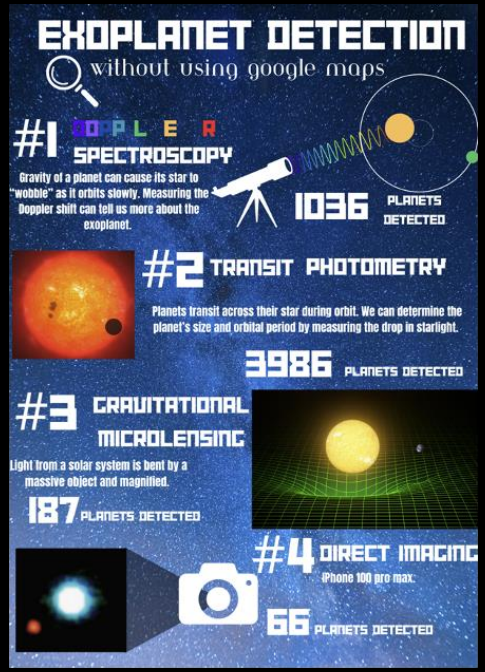
Teamwork: one team only had one person for project

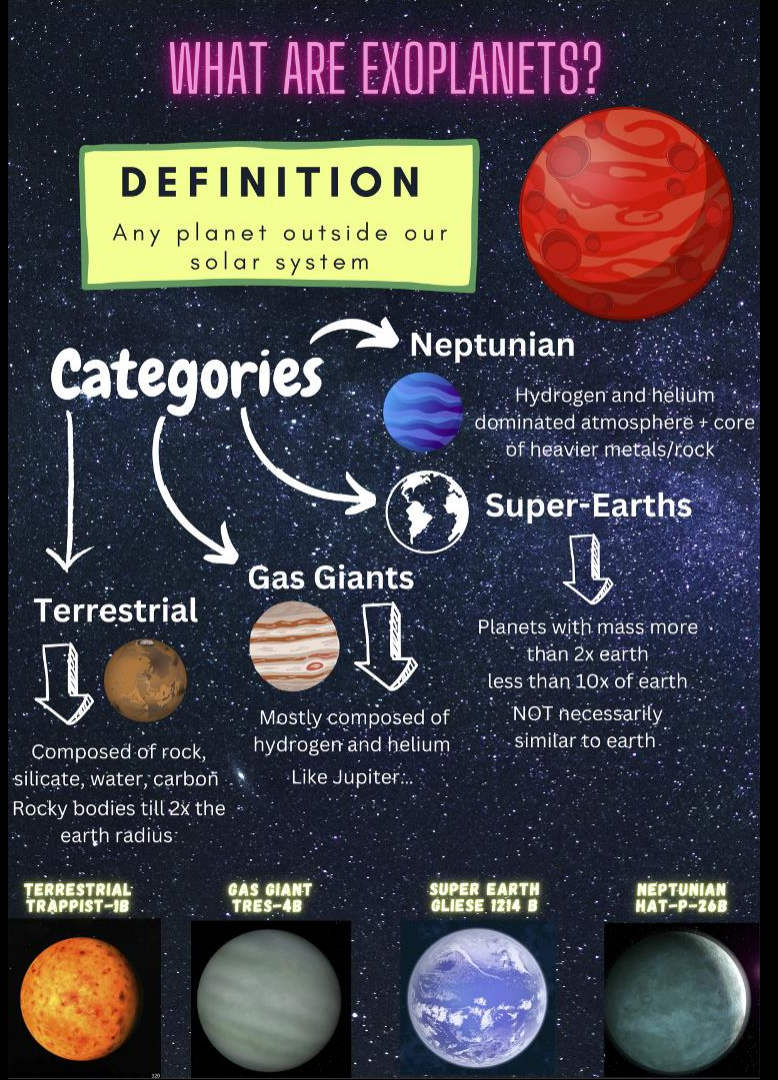
Size of the poster

Good projects

The best for Junior RI/2





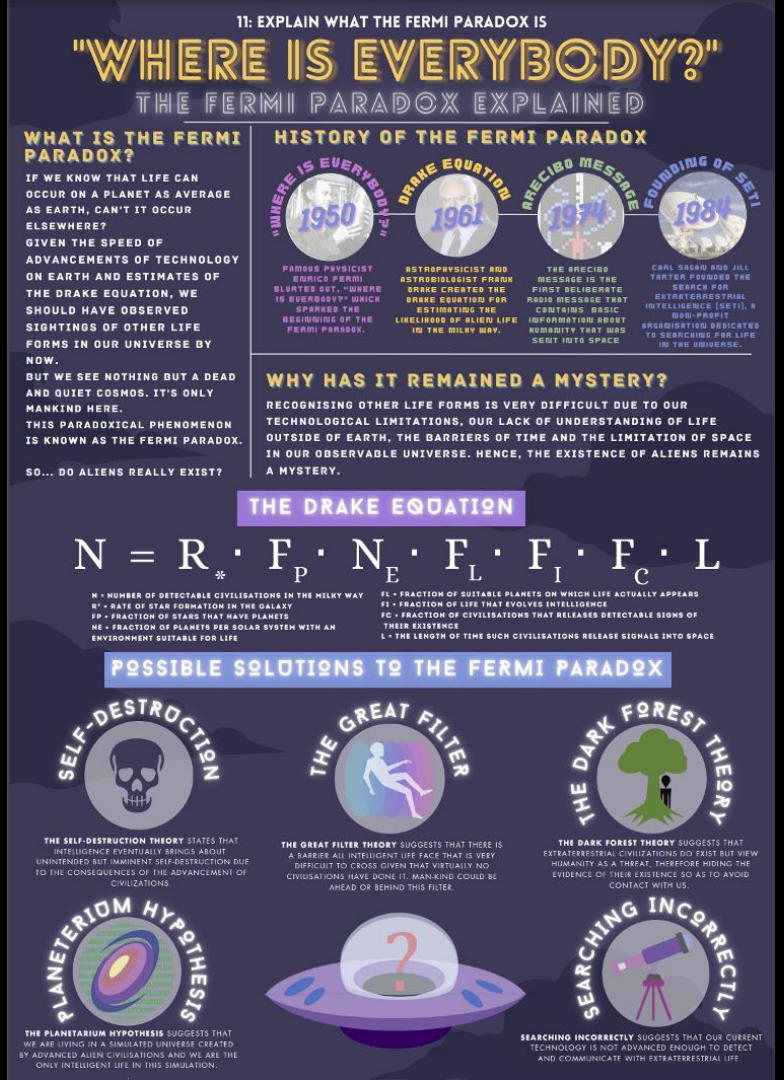


Good projects

Junior Honorable Mention NY/1

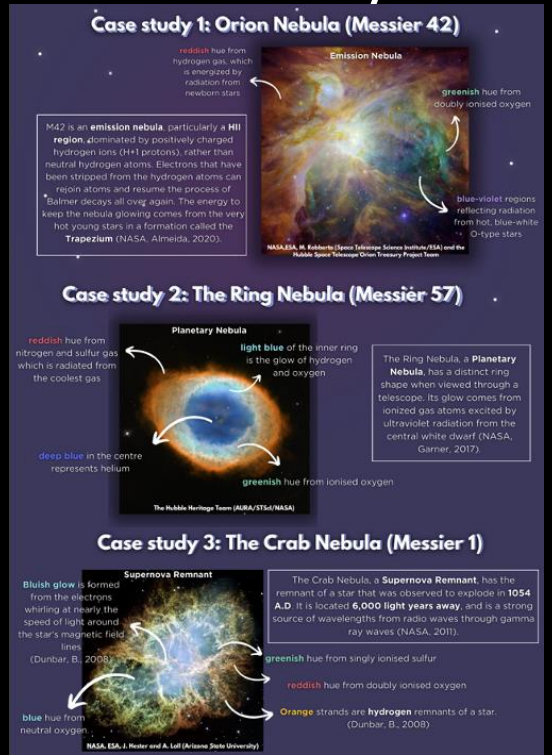
Good projects

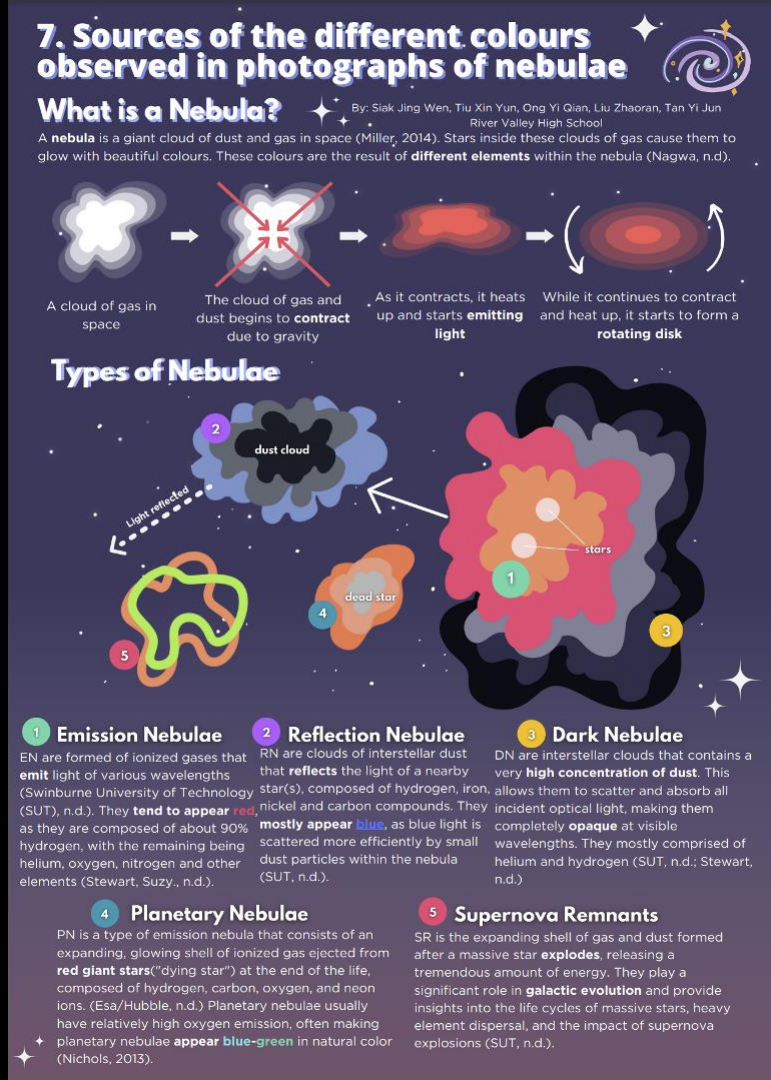
Junior Honorable Mention RV/1



Good projects

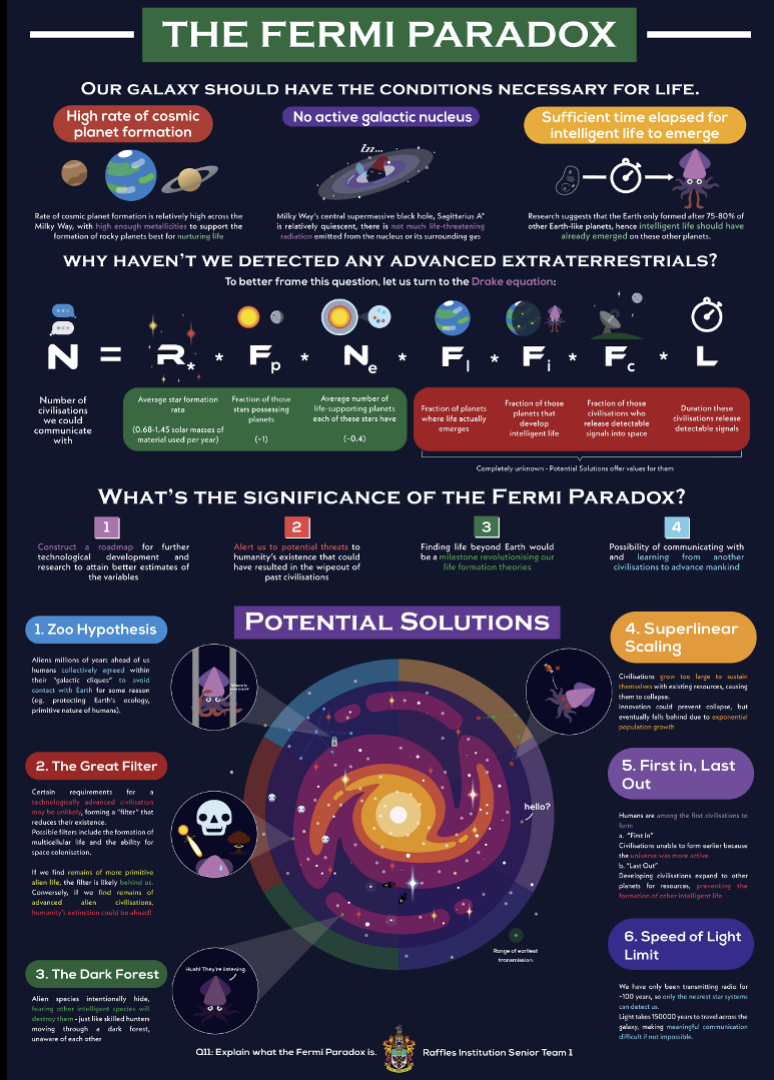
The best for Senior RV/2





Good projects

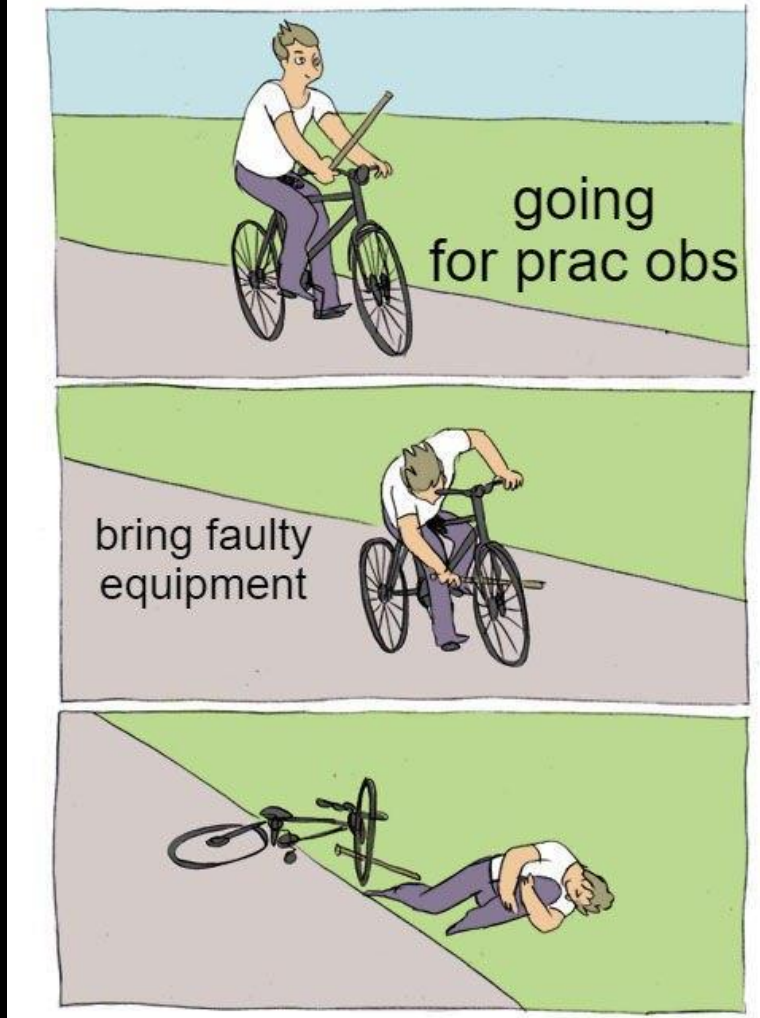
Senior Honorable Mention RI/1



3. Observation Round

Practical


PRAC OBS ROUND ABOUT TO END
CLOUDS
@randysavageaf
imgflip.com


going for prac obs
bring faulty equipment
imgflip.com

Practical

- Section 1 and 2 were generally the same, except some schools who brought a scope that was too low for boresighting
- The main difference maker is section 3
- Some teams were smart enough to spam stars in the last 15mins

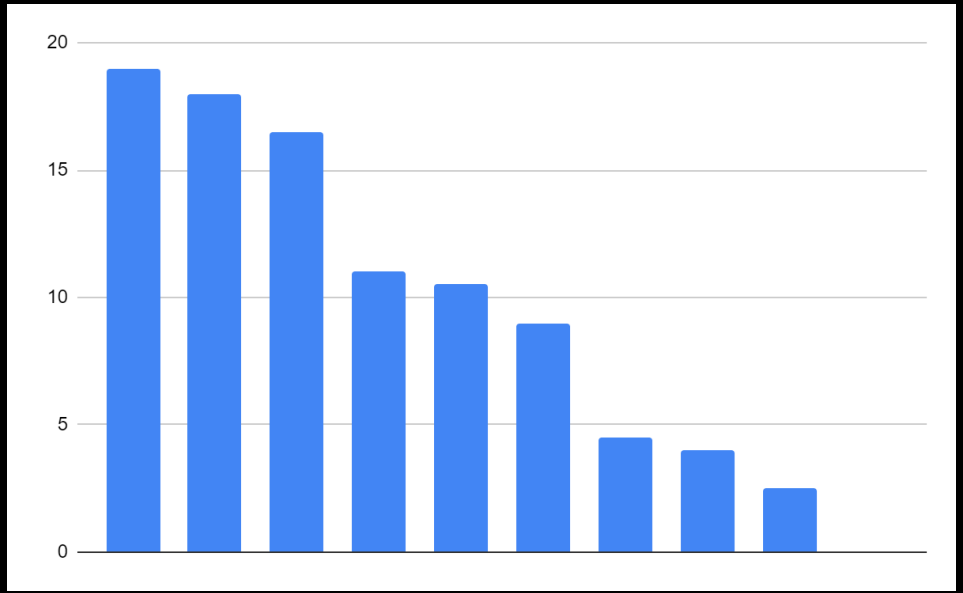
stellar marathon (40%)
40
35
20
20
10
5
5
0
0
0

Theory

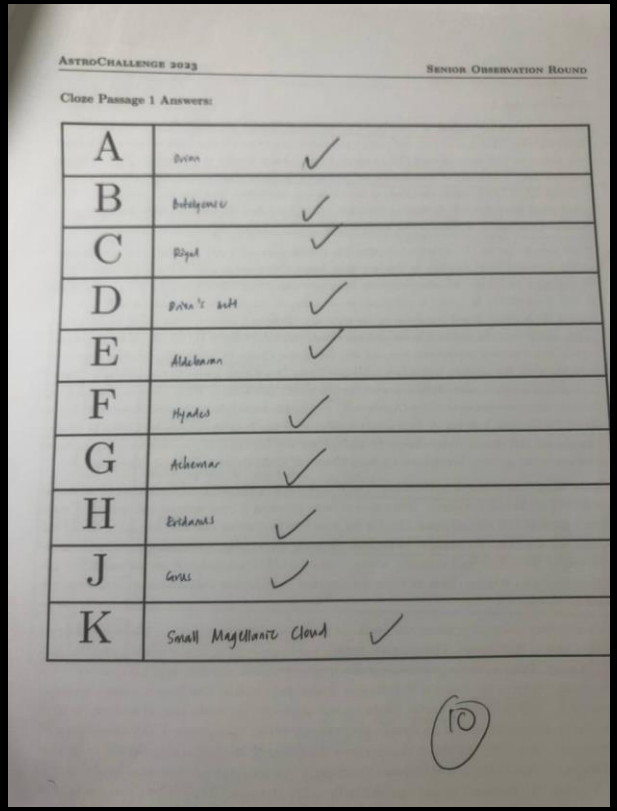
- Teams were split into 2 to prevent solo carrying

Theory Q1 Cloze Passage

Two teams got full marks, but their other half did not get full



Theory Q1 Cloze Passage

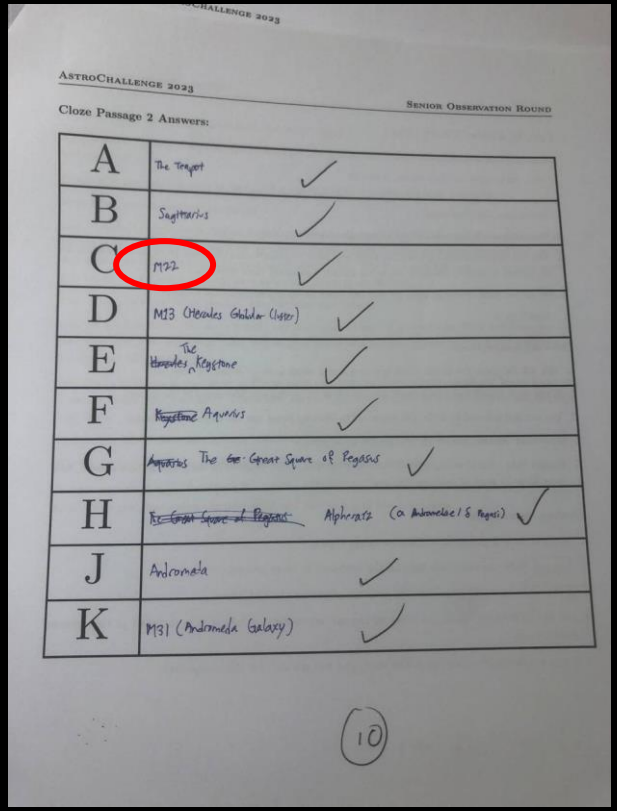


AstroChallenge 2023 — Senior Observation Round

Cloze Passage 1 Answers:

A	Orion ✓
B	Betelgeuse ✓
C	Rigel ✓
D	Orion's belt ✓
E	Aldebaran ✓
F	Hyades ✓
G	Achernar ✓
H	Eridanus ✓
J	Gemini ✓
K	Small Magellanic Cloud ✓

10



AstroChallenge 2023 — Senior Observation Round

Cloze Passage 2 Answers:

A	The Teapot ✓
B	Sagittarius ✓
C	M22 ✓
D	M13 (Hercules Globular Cluster) ✓
E	The Keystone ✓
F	~~Keystone~~ Aquarius ✓
G	~~Aquarius~~ The ~~Great~~ Square of Pegasus ✓
H	~~The Great Square of Pegasus~~ Alpheratz (α Andromedae / δ Pegasi) ✓
J	Andromeda ✓
K	M31 (Andromeda Galaxy) ✓

10

Only the full marks team got this correct. Yall should try finding M22 next time, can be seen Singapore on a good clear sky

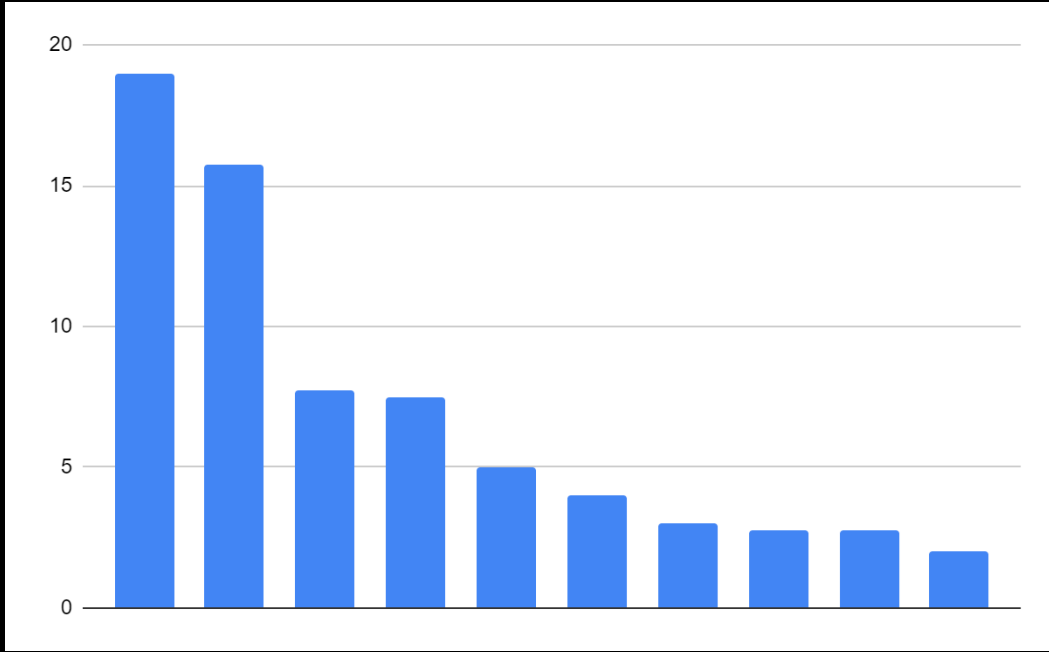
Theory Q2 Finder Charts

3 teams managed to find

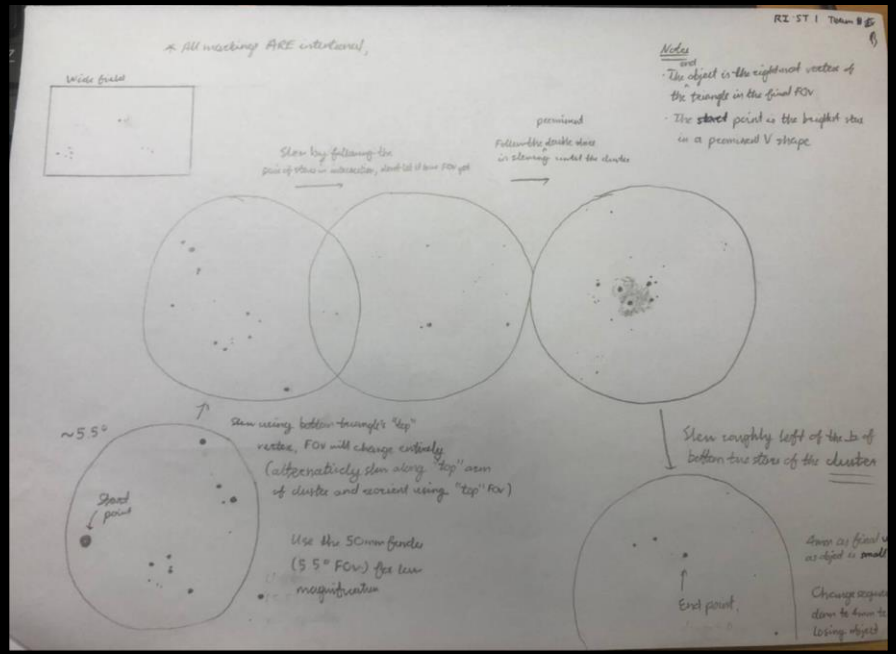
2 of them from the same school

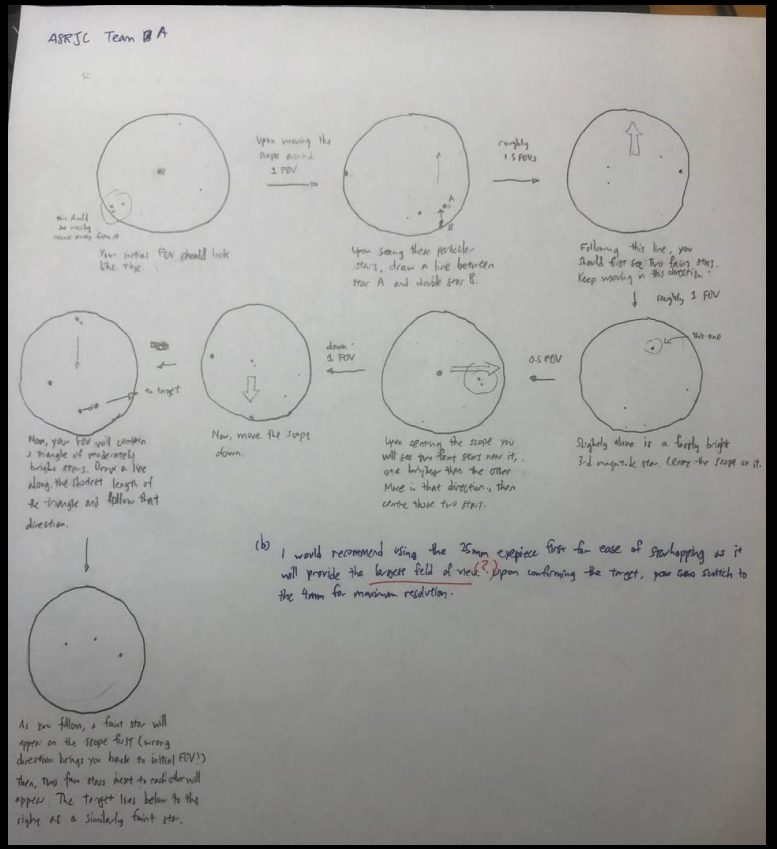
Please have a drawing that can be read easily >.<

More practice is needed



Theory Q2 Finder Charts

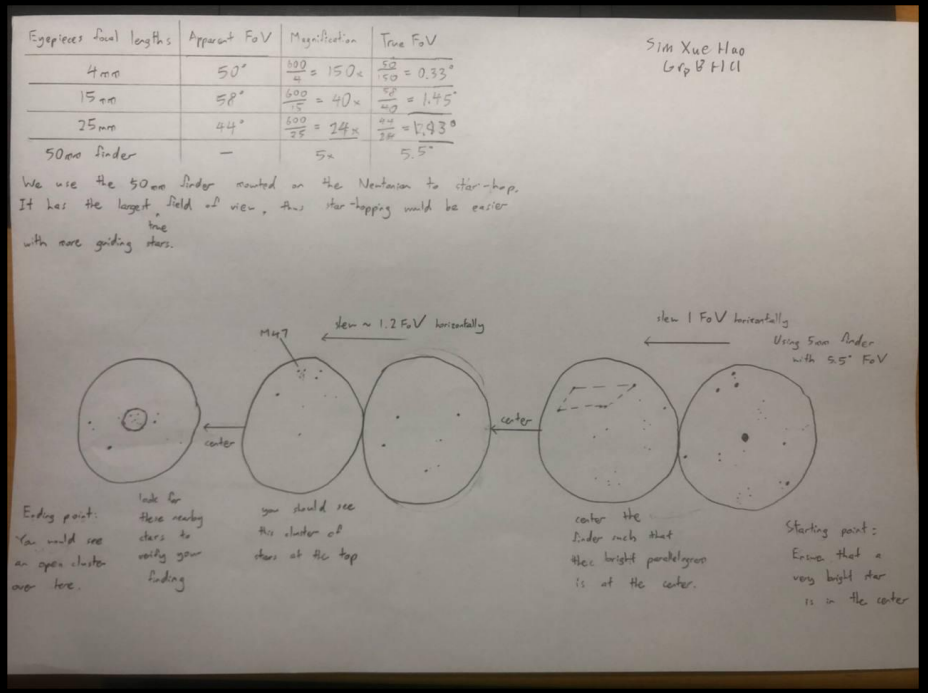


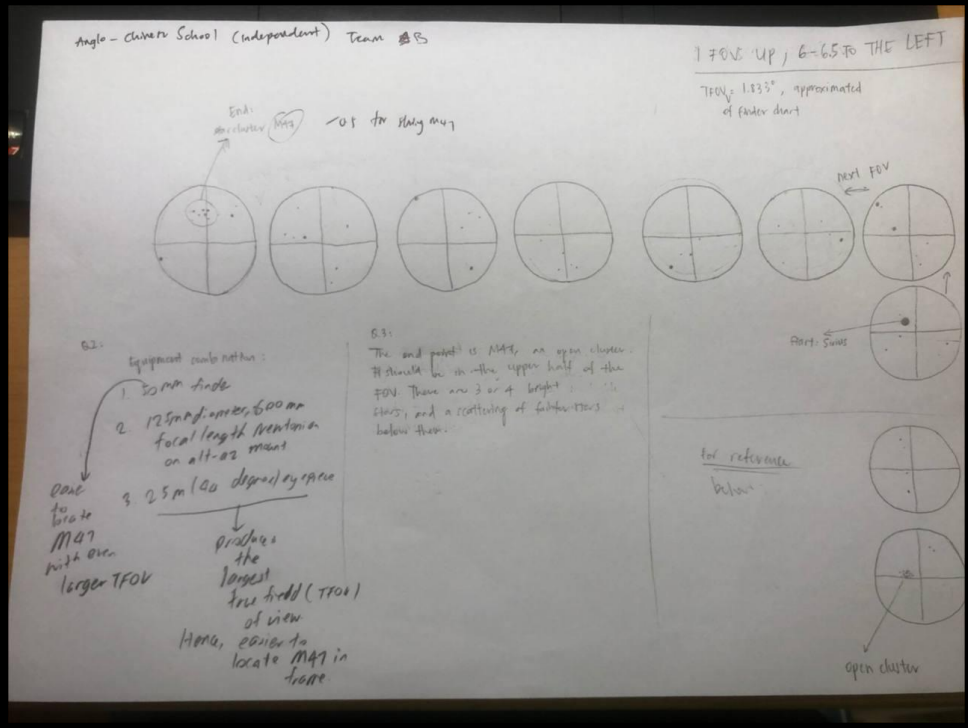


Always use a finder!!!

Count number of FOVs!!!

Theory Q2 Finder Charts

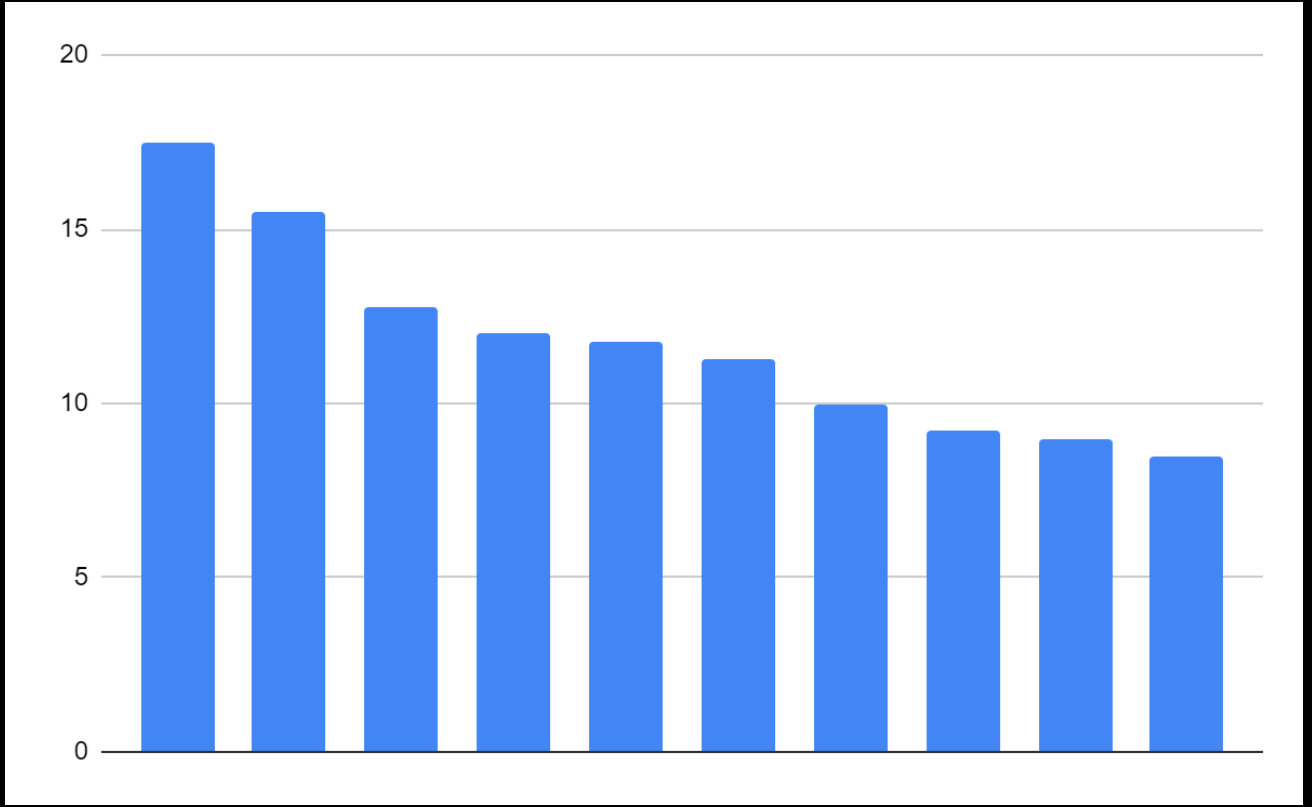




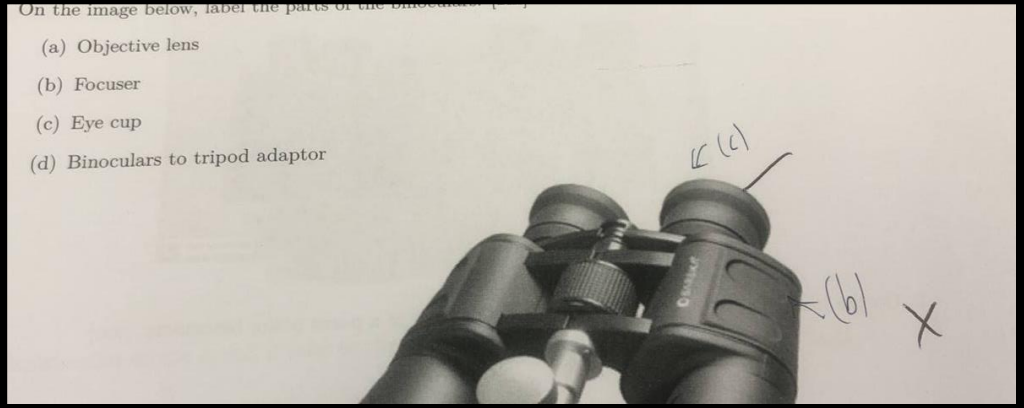
Where do I start and end??

What am i supposed to look out for??

Theory Q3 Equipment

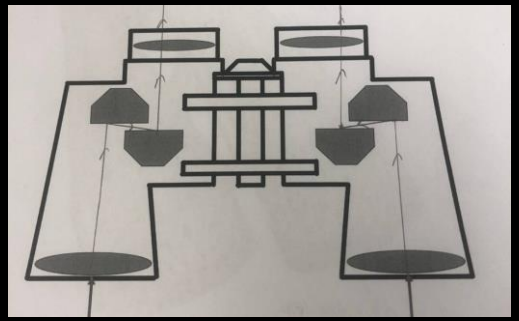


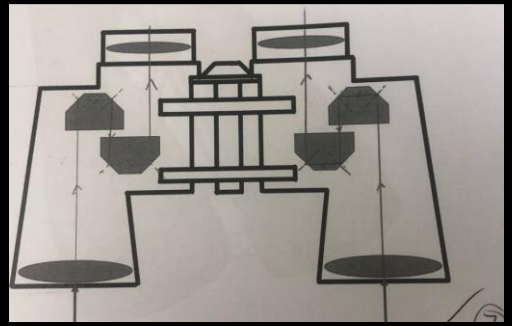
Theory Q3 Equipment

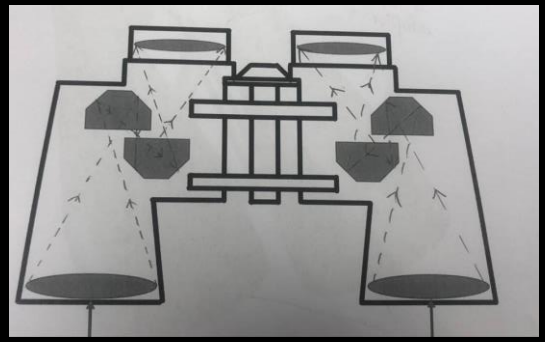


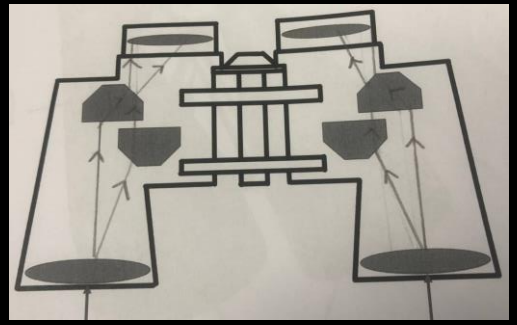
Press rubber to focus?

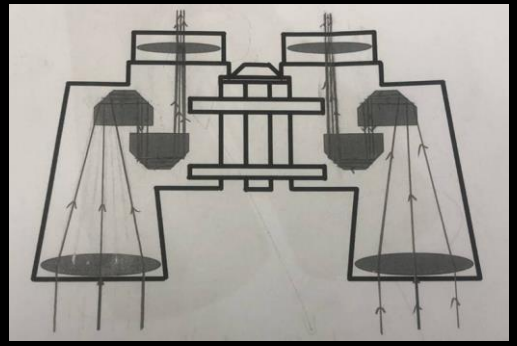
Theory Q3 Equipment











Which is correct?

Theory Q3 Equipment

specifications is 10×50.

Eye cups can be magnifie

3. Explain what do the A and B refer to. [1m]

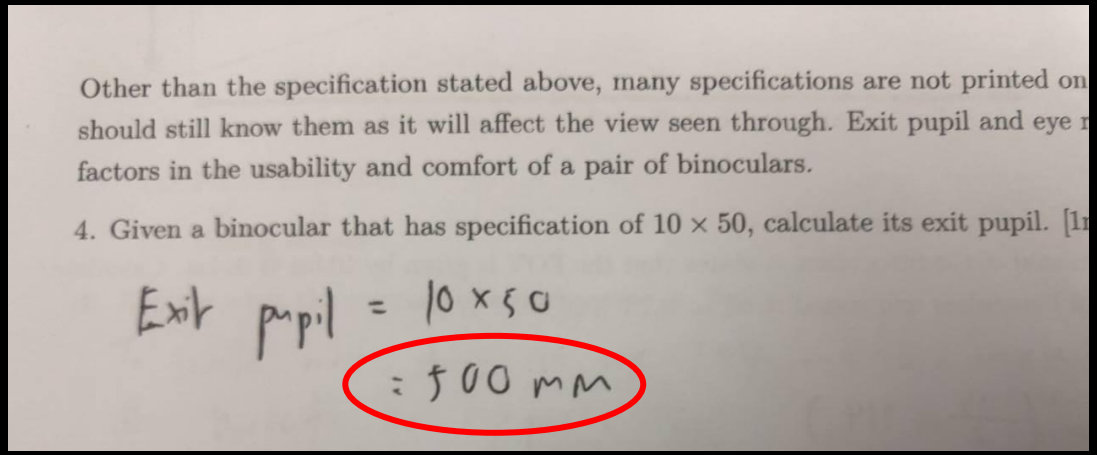
A is Magnification of objective lens

B is magnification of ~~eyepiece~~ eye cup.

Other than the specification stated above, many specifications are not printed on the should still know them as it will affect the view seen through. Exit pupil and eye relie factors in the usability and comfort of a pair of binoculars.

4. Given a binocular that has specification of 10×50, calculate its exit pupil. [1m]

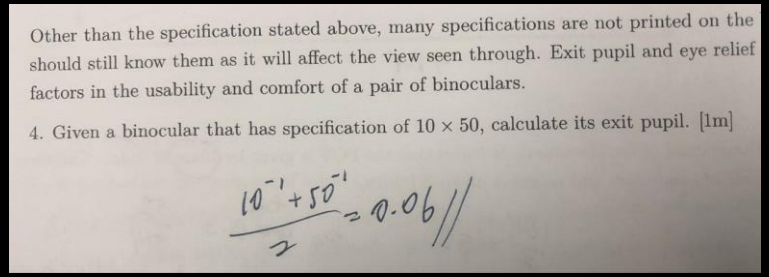
Theory Q3 Equipment


Other than the specification stated above, many specifications are not printed on
should still know them as it will affect the view seen through. Exit pupil and eye r
factors in the usability and comfort of a pair of binoculars.

4. Given a binocular that has specification of 10 × 50, calculate its exit pupil. [1r

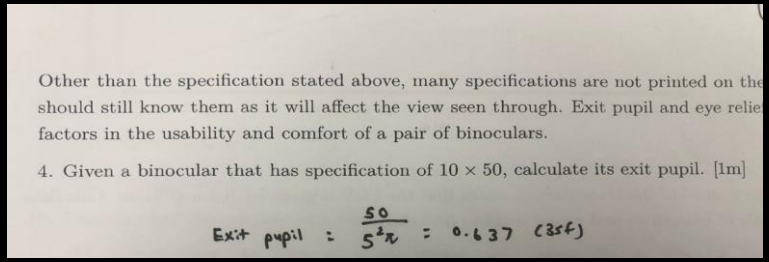
Exit pupil = 10 × 50

= 500 mm


Other than the specification stated above, many specifications are not printed on the
should still know them as it will affect the view seen through. Exit pupil and eye relief
factors in the usability and comfort of a pair of binoculars.

4. Given a binocular that has specification of 10 × 50, calculate its exit pupil. [1m]

$\frac{10^{-1}+50^{-1}}{2} = 0.06$ //


Other than the specification stated above, many specifications are not printed on the
should still know them as it will affect the view seen through. Exit pupil and eye relief
factors in the usability and comfort of a pair of binoculars.

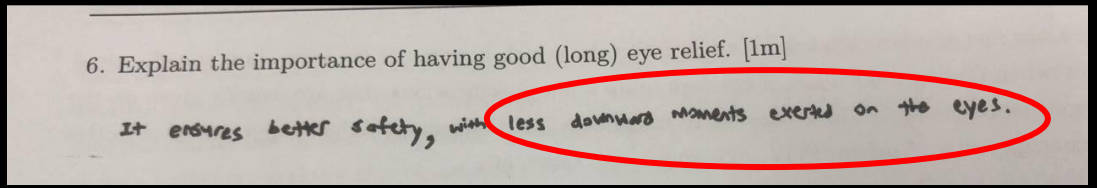
4. Given a binocular that has specification of 10 × 50, calculate its exit pupil. [1m]

Exit pupil : $\frac{50}{5^2\pi}$: 0.637 (3sf)

Weird calculations

Theory Q3 Equipment

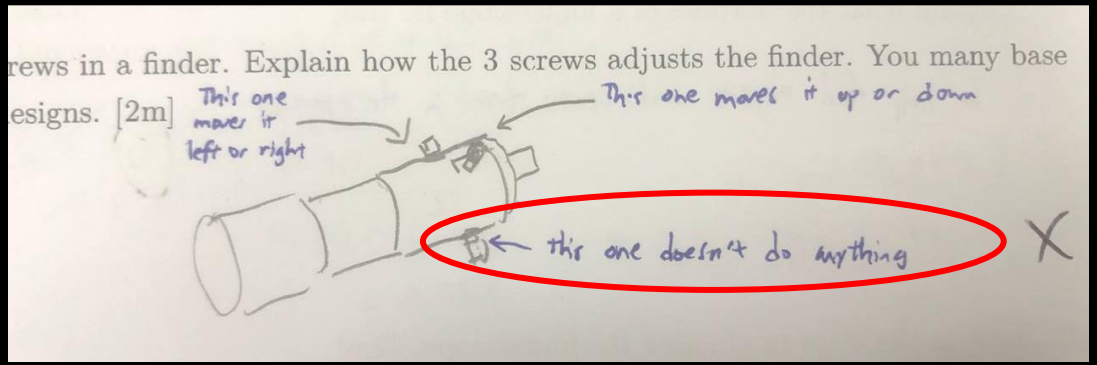
Are your eyes glued to the binos?



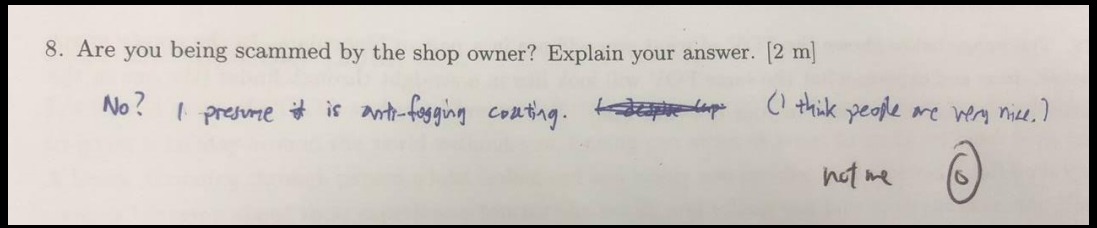
6. Explain the importance of having good (long) eye relief. [1m]

It ensures better safety, with less downward moments exerted on the eyes.

Theory Q3 Equipment

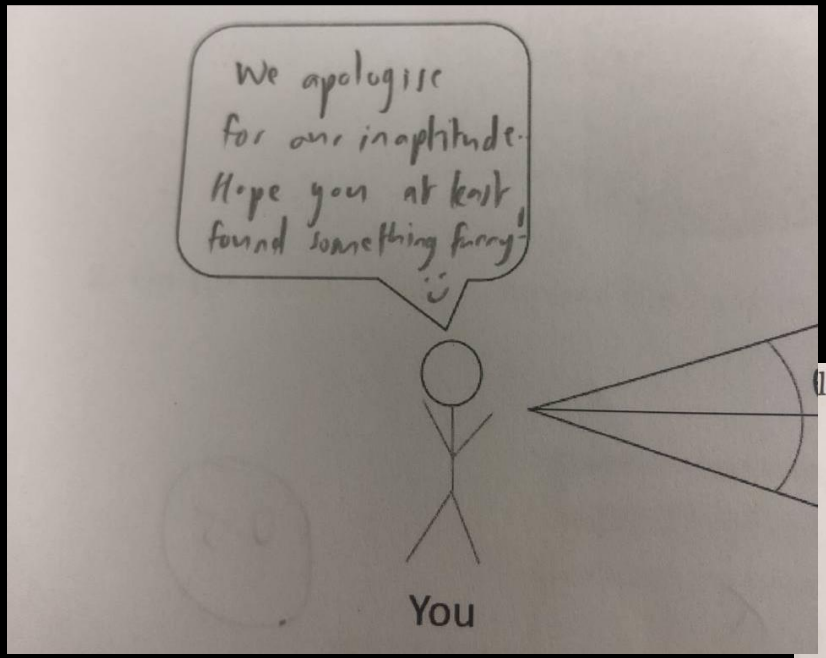


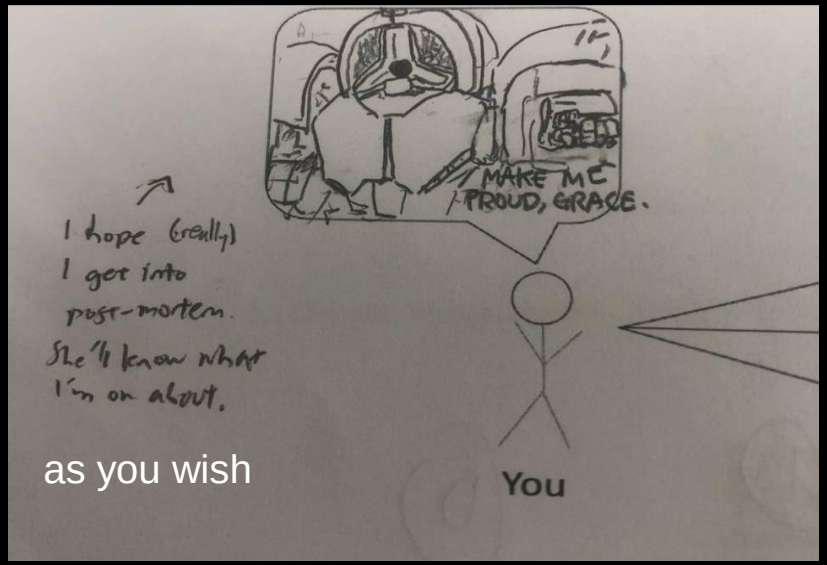
Why have it there if it does not do anything



Not so nice

Theory Q3 Equipment





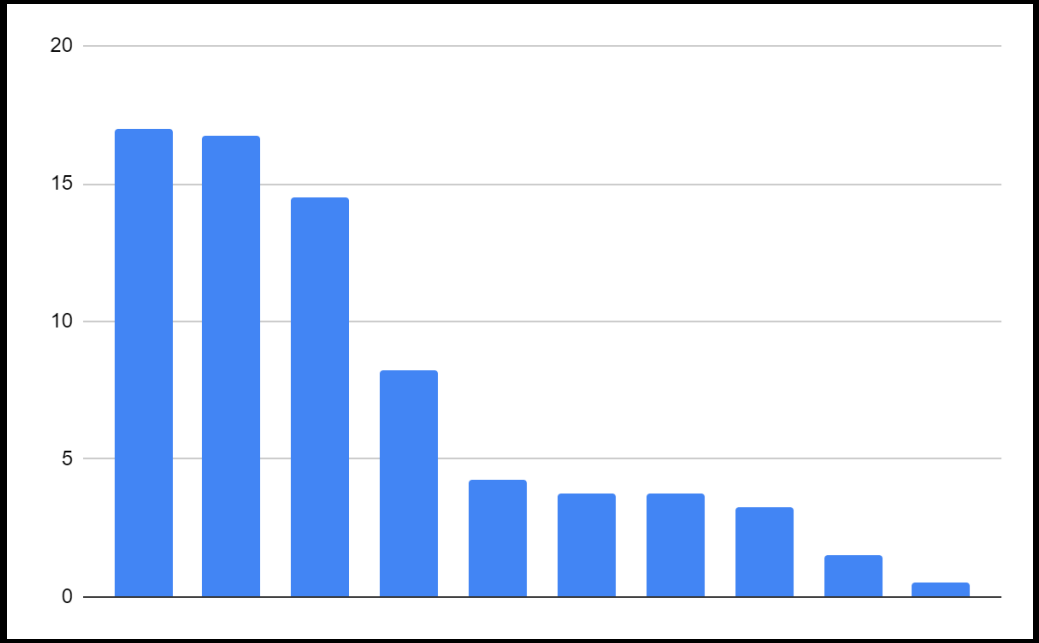
lar that has specification of 10×50, calculate its exit pupil. [1m]

$\frac{10}{50} = 0.2$

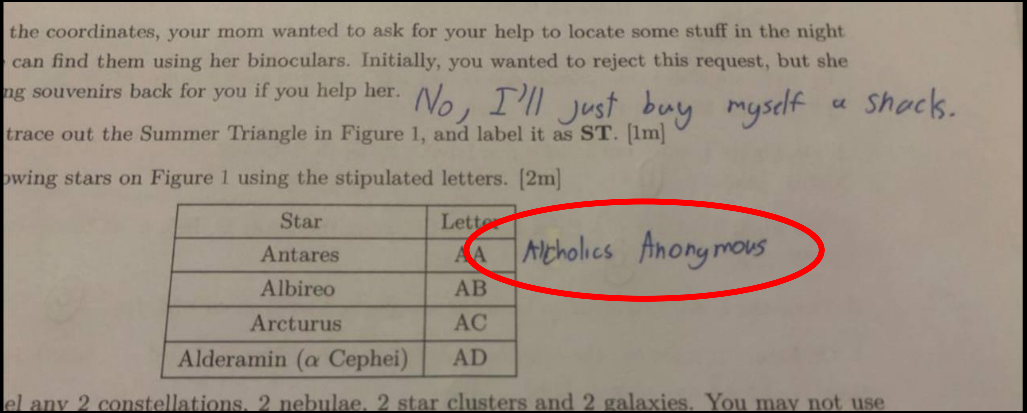
Nope . .

pacts of having a too large and too small exit pupil. [2m]

Theory Q4 Night Sky



Theory Q4 Night Sky



the coordinates, your mom wanted to ask for your help to locate some stuff in the night
can find them using her binoculars. Initially, you wanted to reject this request, but she
ng souvenirs back for you if you help her. No, I'll just buy myself a snack.

trace out the Summer Triangle in Figure 1, and label it as **ST**. [1m]

owing stars on Figure 1 using the stipulated letters. [2m]

Star	Letter
Antares	AA
Albireo	AB
Arcturus	AC
Alderamin (α Cephei)	AD

Alcholics Anonymous

el any 2 constellations, 2 nebulae, 2 star clusters and 2 galaxies. You may not use

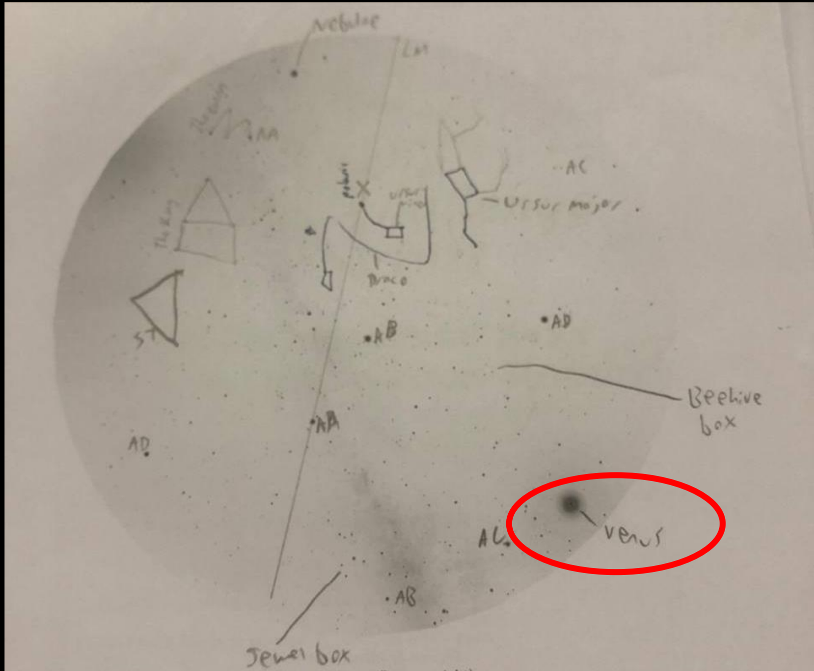
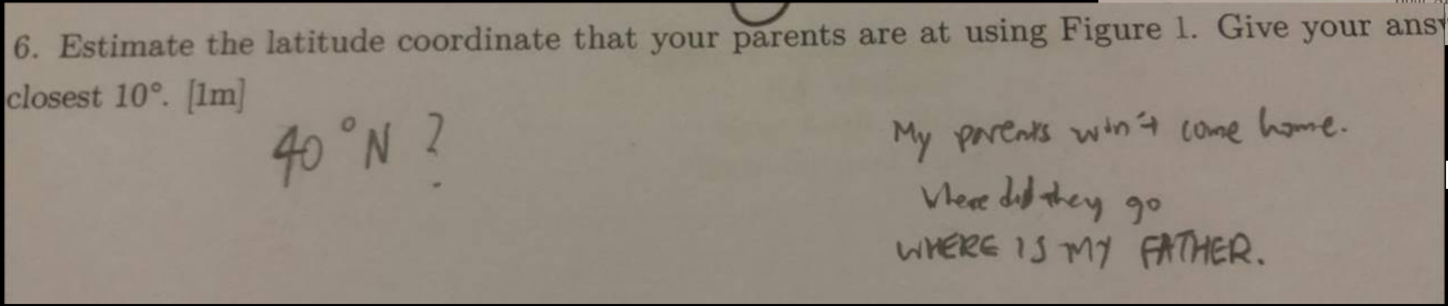


Figure 1: Moon (bottom right)
Hour Angle: 3h15m
ereal Time: ?



6. Estimate the latitude coordinate that your parents are at using Figure 1. Give your ans
closest 10°. [1m]

40 °N ?

My parents won't come home.
Where did they go
WHERE IS MY FATHER.

Im sorry :(

Theory Q4 Night Sky

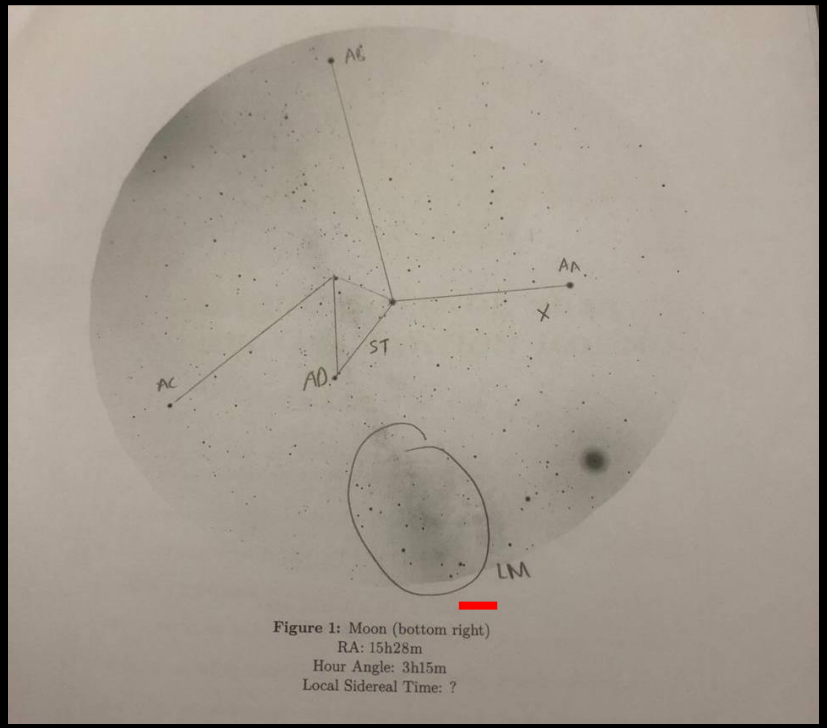
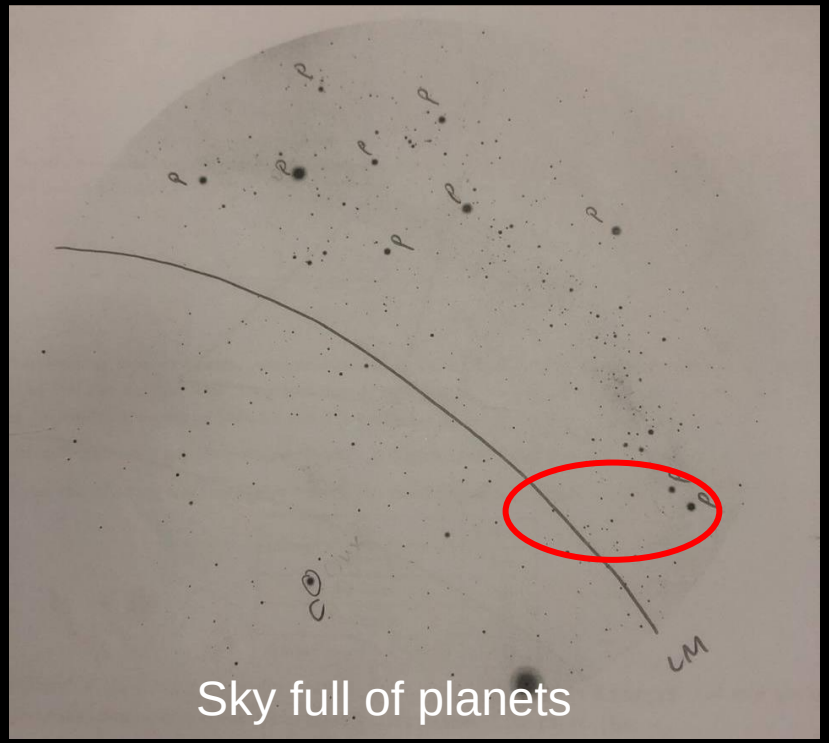
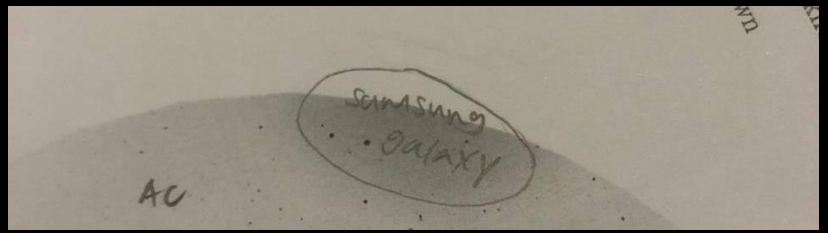


Figure 1: Moon (bottom right)
RA: 15h28m
Hour Angle: 3h15m
Local Sidereal Time: ?

Pretty sure local meridian is a line

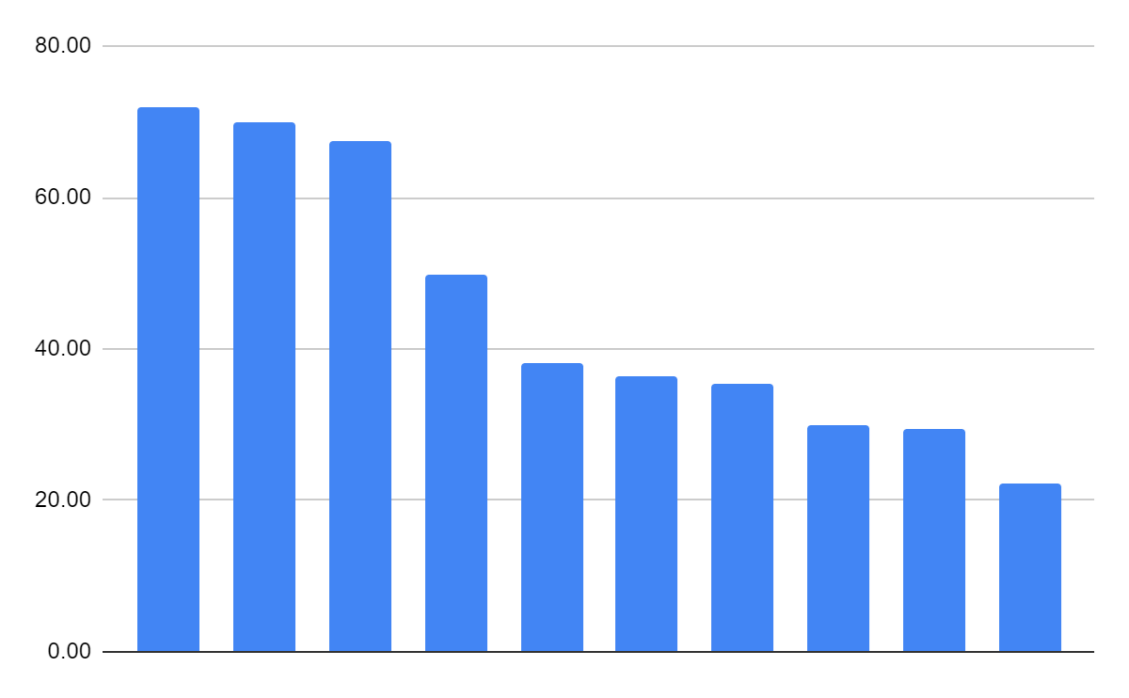


Sky full of planets

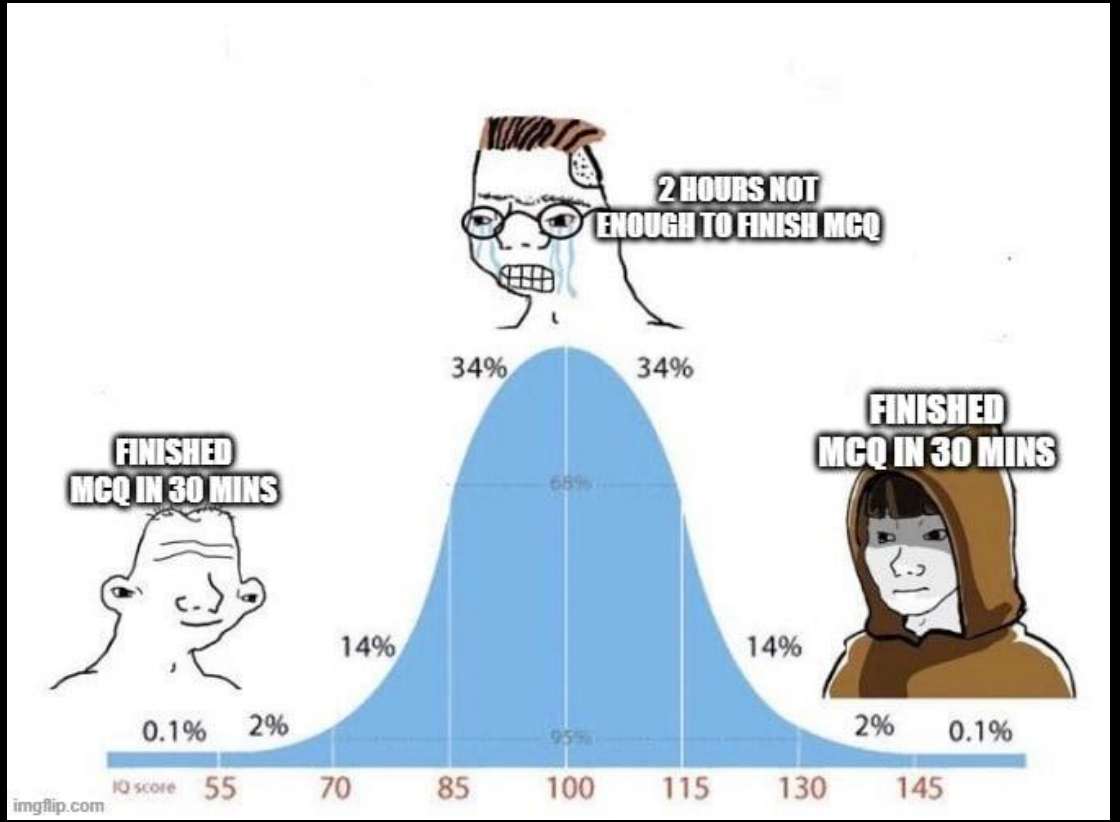


Overall

- Top 3 are very close



4. MCQ Round


2 HOURS NOT ENOUGH TO FINISH MCQ
FINISHED MCQ IN 30 MINS
FINISHED MCQ IN 30 MINS
34%
34%
14%
14%
0.1%
2%
2%
0.1%
68%
95%
IQ score
55
70
85
100
115
130
145
imgflip.com

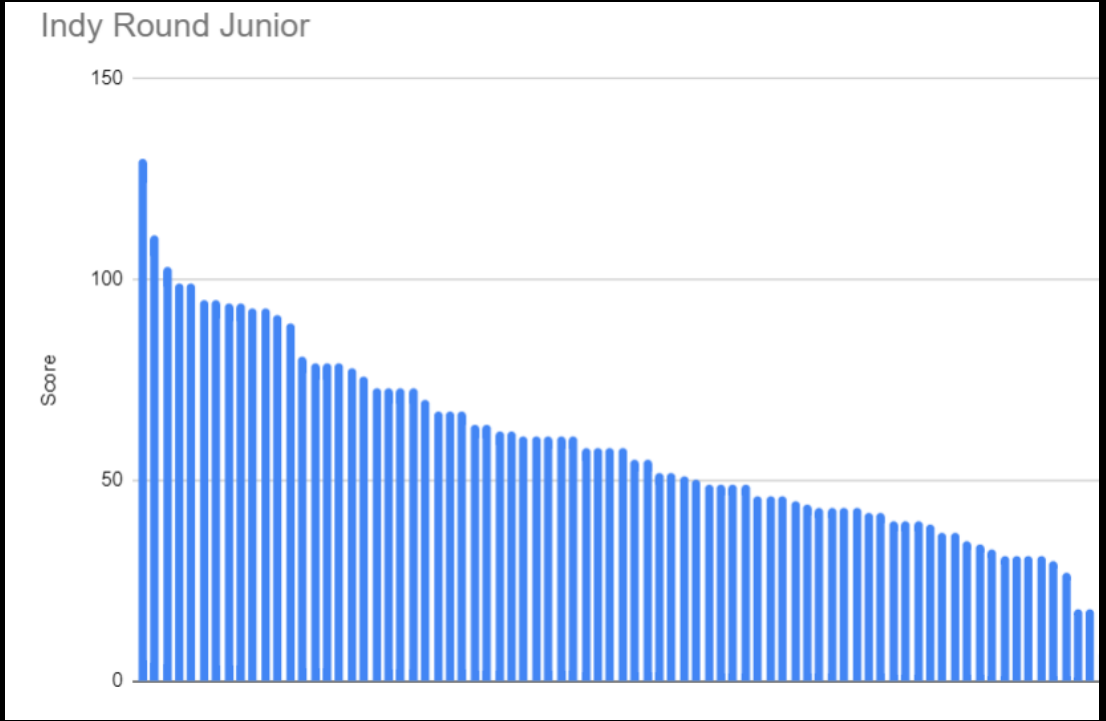
MCQ Junior

Mean: 59.7

Median: 58

Max: 130

Min: 18



MCQ Junior - Confusing??

Most blanks: Q11

11. One tropical year is the time the Sun takes to return to the same solstices or equinoxes, while the sidereal year is the time the Sun to return to the same position relative to distant stars.

Given that a sidereal year is longer than a tropical year, looking from the north ecliptic pole to the south ecliptic pole, which of the following describes the rotation of the **first point of Aries** and the **first point of Libra** on the ecliptic plane compared to distant stars?

(A) Counter-clockwise,clockwise

(B) **Clockwise, clockwise**

(C) Counter-clockwise, counter-clockwise

(D) Clockwise, counter-clockwise

(E) Both points do not move compared to distant stars

MCQ Junior - Misled…

Most Incorrects: Q40

40. From the point of view of someone on Mars, which of the following appear to be *incorrect*? The planets are in opposition from an Earth observer.

(A) Jupiter will appear larger in the night sky than on Earth due to its closer distance

(B) Earth's apparent size from Mars is larger than Mars' apparent size from Earth

(C) **The Sun will appear brighter to an observer on Mars than on Earth due to Mars having less atmosphere**

(D) Stars will appear dimmer in general to an observer on Mars

(E) More than one of the above statements are incorrect

MCQ Junior - Piece of Cake?

Most Corrects: Q28

28. Why does Mars appear red to the naked eye?

(A) **The Martian surface is rich in iron oxides, which appear red**

(B) Mars is a black body and thus emit red light by Wien's Law

(C) Widespread volcanic activity in the Tharsis Montes region emits significant amount of red light

(D) Raging wildfires on its surface emit red light

(E) Mars is not red, it only appears red due to post-processing

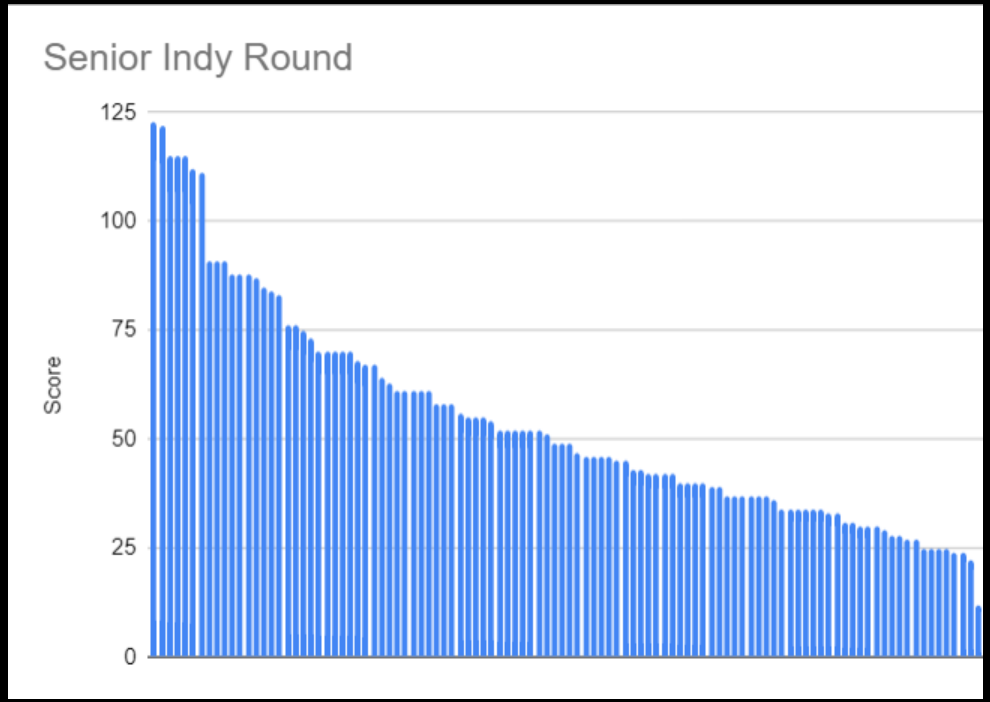
MCQ Senior

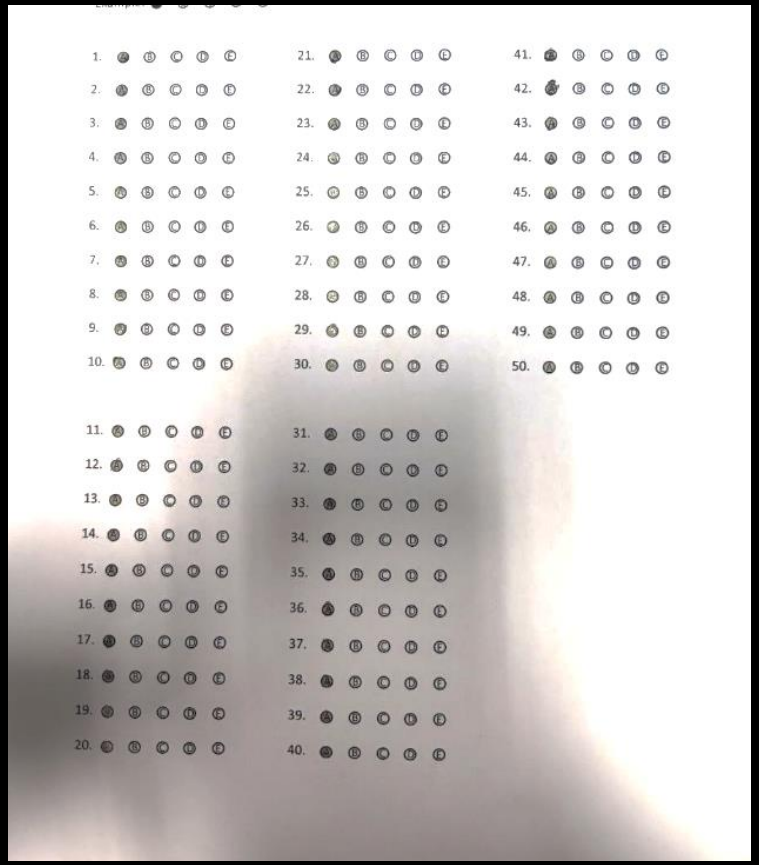
Mean: 54.2

Median: 49

Max: 123

Min: 12





Two of such “straight-As” sheet are found

Fun Fact: You can beat the individual average by just answering C in Senior round…

MCQ Senior - A Surprise

Most blanks (tied):
Q16 and Q26

26. Given that an eyepiece of 15mm focal length and Apparent Field-of-View (AFOV) of 70°is used on Telescope B. Calculate the True Field-of-View (TFOV) of the setup.

(A) 0.432°

(B) **0.827°**

(C) 1.43°

(D) 2.04°

(E) 2.89°

MCQ Senior - A Surprise

Most Incorrects: Q1

1. Which of the following are **not** one of the ways astronomers measure the Hubble's constant?

   (A) Using the merger of two black holes or neutron stars and measuring the subsequent gravitational waves to get their relative speeds to Earth

   (B) **Using the flat rotational curve model and absolute magnitude of Active Galactic Nuclei (AGN) to get their relative speeds to Earth**

   (C) Using spectroscopic analysis of a distant object of known distance to determine its relative redshift to Earth

   (D) Use bubbles in the CMBR and the flat universe model to determine the distance of certain Supernovae to determine its relative speed to Earth

   (E) All of the above methods are valid methods of measuring Hubble's constant

MCQ Senior - A Surprise

Most Corrects: Q6

6. Black holes are regions of space where matter collapsed in on itself, creating a singularity. This collapse is so strong that not even light can escape the black hole's gravity. As a result, black holes are often described as being "invisible" because they do not emit any light or other radiation that we can detect.

What methods do scientists use to measure the mass of "invisible" black holes?

i Direct modeling of the motions of resolved stars that are in orbit near the black hole

ii Finding them in binary systems and measuring the motion of the companion object

iii Measurement of emitted gravitational waves in black hole mergers

iv Measuring the temperature difference between the black hole's core and event horizon

(A) i and ii

(B) ii and iii

(C) i and iv

(D) **i, ii, and iii**

(E) All of the above

Common Pool Questions

Some questions are present in both JNR and SNR. How does the two categories compare?

JNR		
Qn No.	Corrects	Incorrects
26	23%	77%
42	39%	61%
44	27%	73%
45	49%	51%
46	24%	76%
47	48%	52%
48	35%	65%
49	62%	38%
50	33%	67%

SNR		
Qn No.	Corrects	Incorrects
25	23%	77%
32	55%	45%
34	30%	70%
36	55%	45%
37	23%	77%
38	46%	54%
39	43%	57%
40	53%	47%
41	39%	61%

47. The James Webb Space Telescope is one of the most anticipated space telescopes with an immense budget. Because it is primarily designed for near-infrared astronomy, it must be positioned at the L2

49. Unlike planets like Earth and Uranus, Jupiter does not experience significant seasonal changes. This is primarily because

(A) Jupiter is tidally locked to the Sun

(B) Jupiter moves too slowly along its orbit

(C) **The axial tilt of Jupiter is negligible**

(D) The weather on Jupiter is driven by tidal forces exerted by the Galilean moons

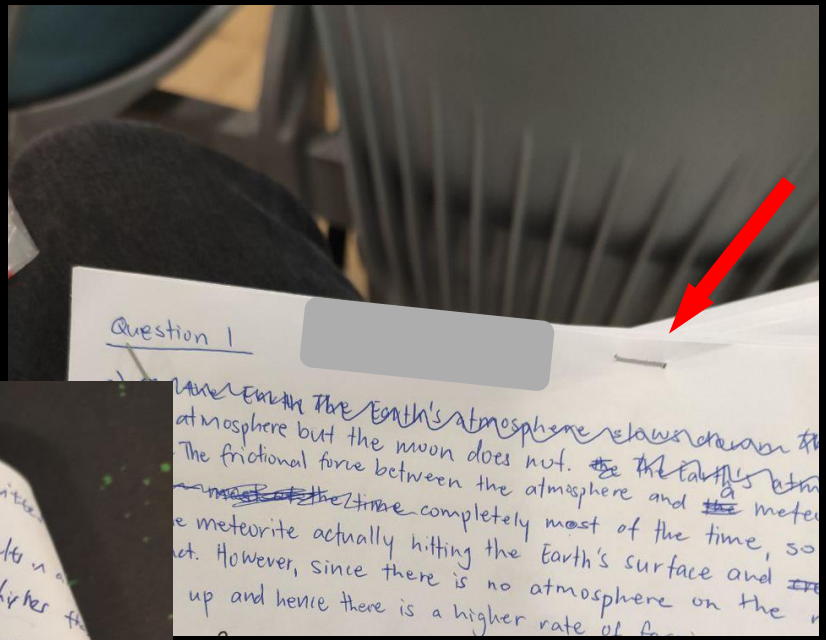
(E) The weather on Jupiter is driven by deuterium fusion within its core

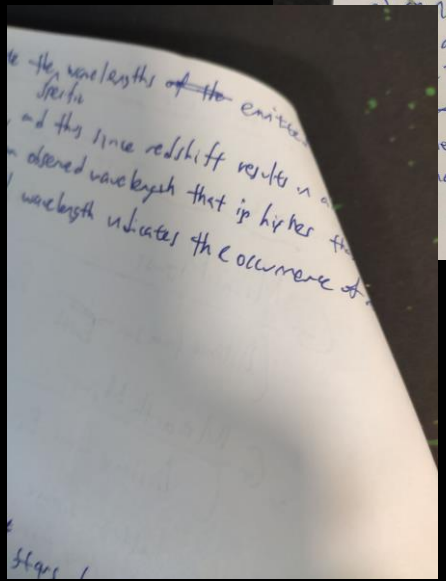
(E) None of the above

6. DRQ Round

Minor Bugbear

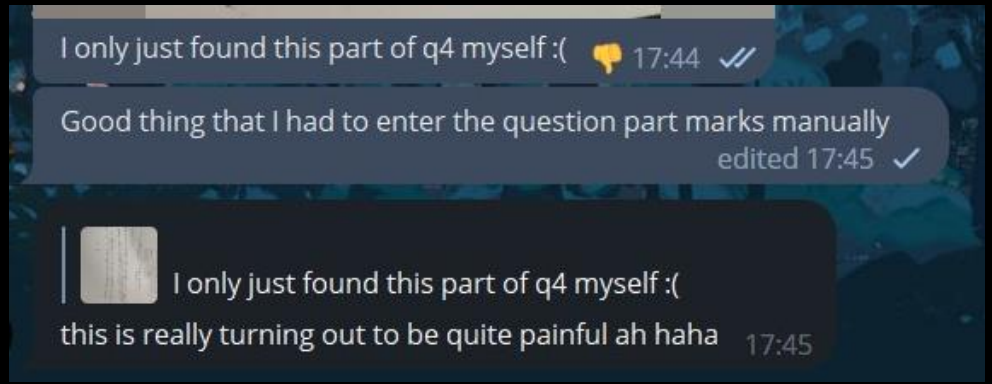
- Annoying stapling practices



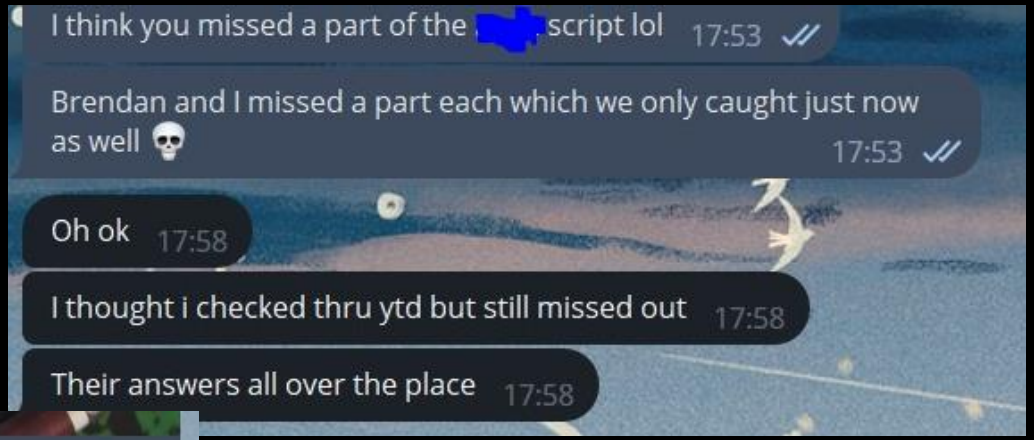


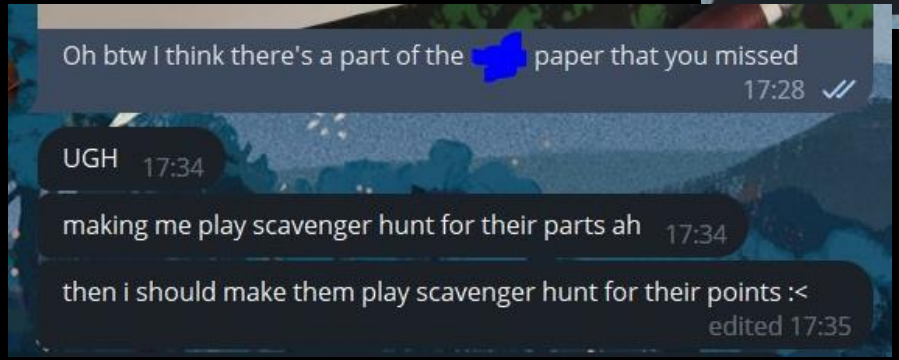
Not So Minor Bugbear

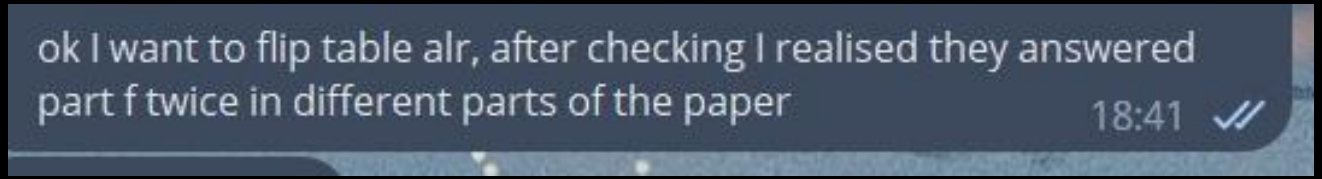
- To facilitate the marking, we requested for separate questions to be answered on separate papers…for a good reason…



- The saga continues…







5.1 Junior DRQ

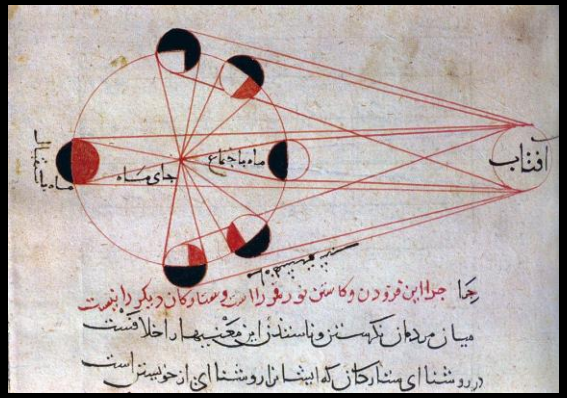



Image: space.com

Image: Kurzgesagt

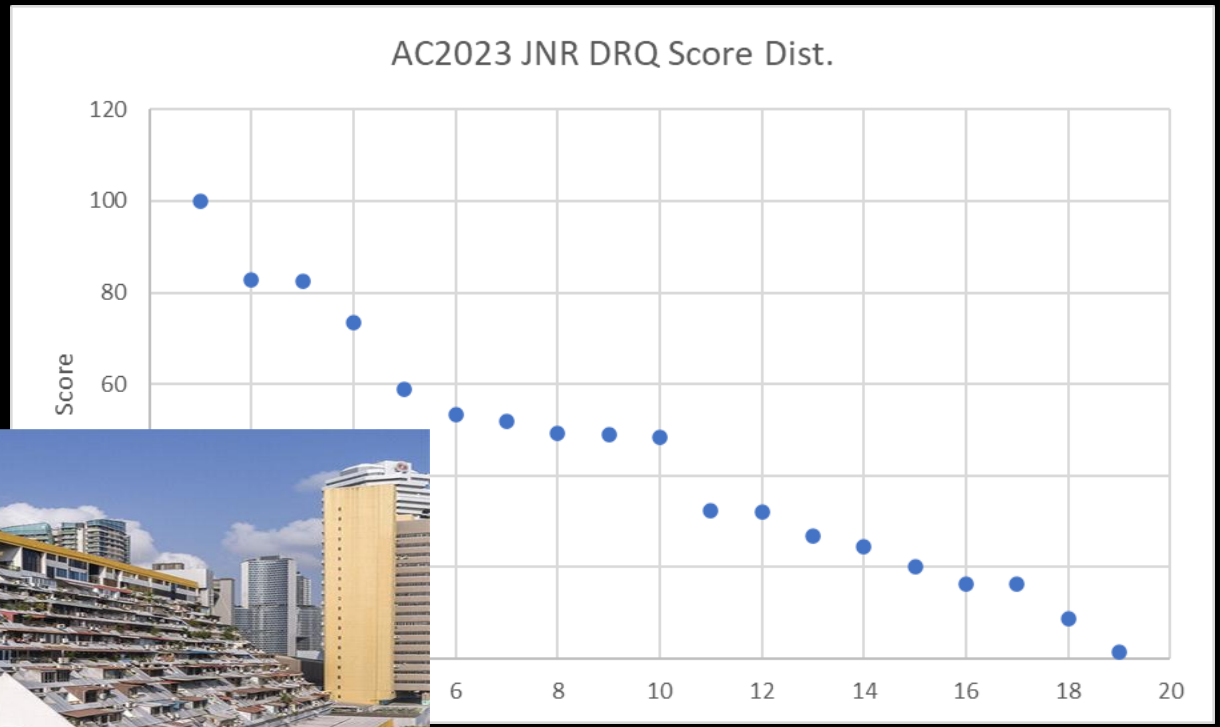
Statistics

After Moderation:

Mean: 43.60

Median: 48.44

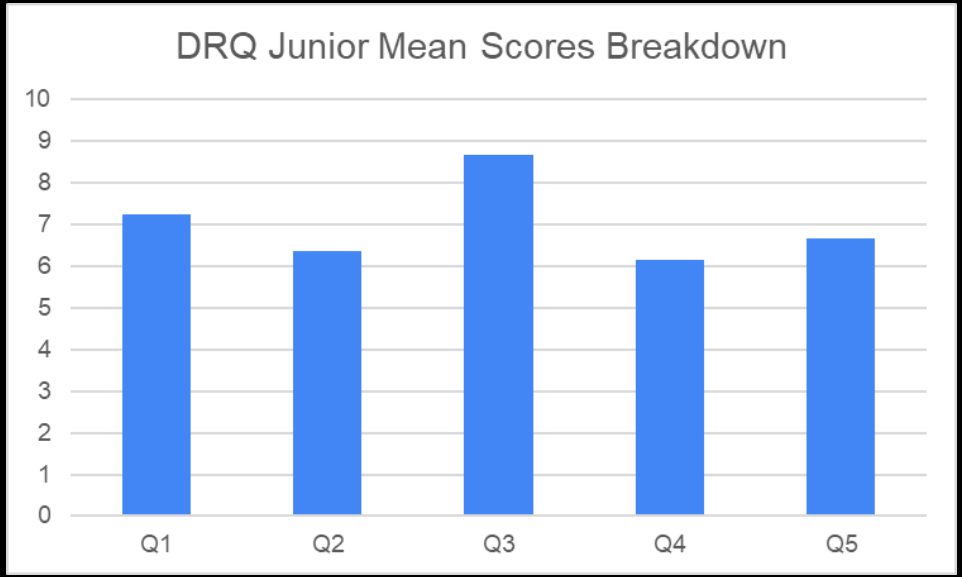
HI: 100



Score Breakdown

- Expectation: better scores for Q1 (general astronomy) and Q5 (practical astronomy) than Q2/Q3/Q4

- Reality: most participants can do some math (Q3) but not astronomy :(



Q1

A Job Interview

NPZ

Rationale

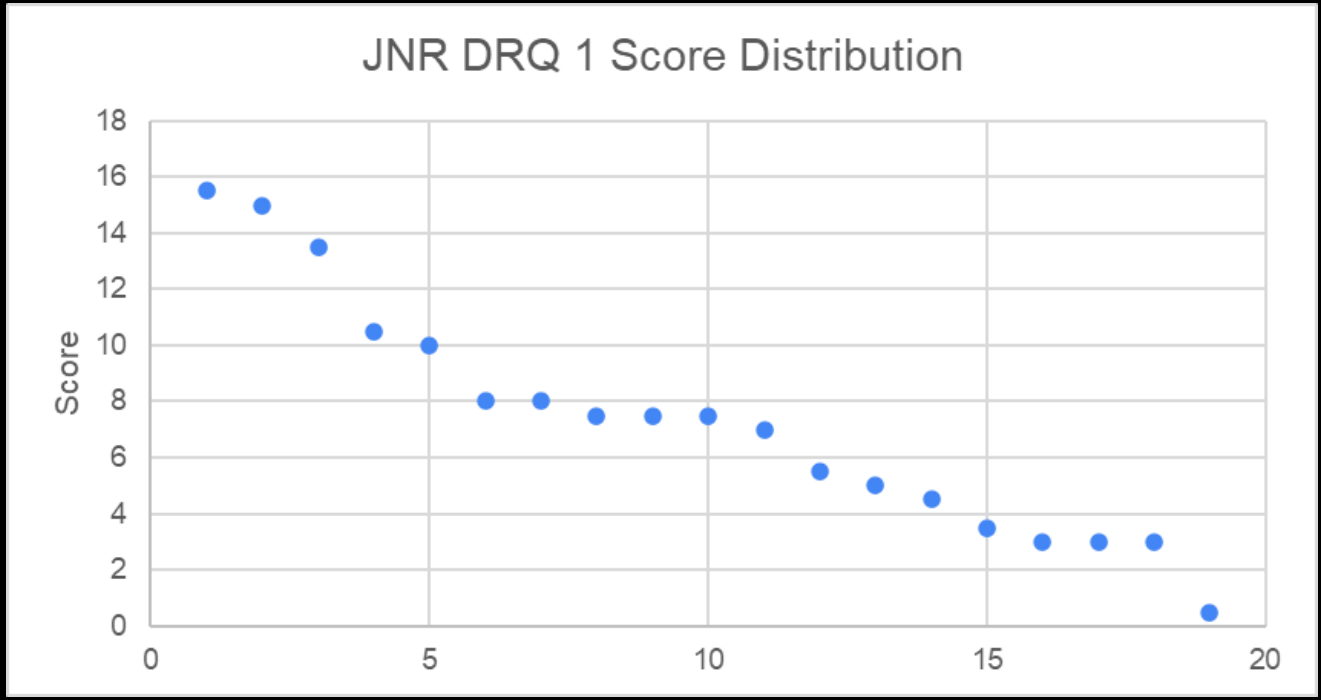
- Easy-to-score general astronomy question
- Provide a score buffer for the inevitable slaughter in the later questions

Reality:

- Participants don’t have a strong grasp on general astronomy :(

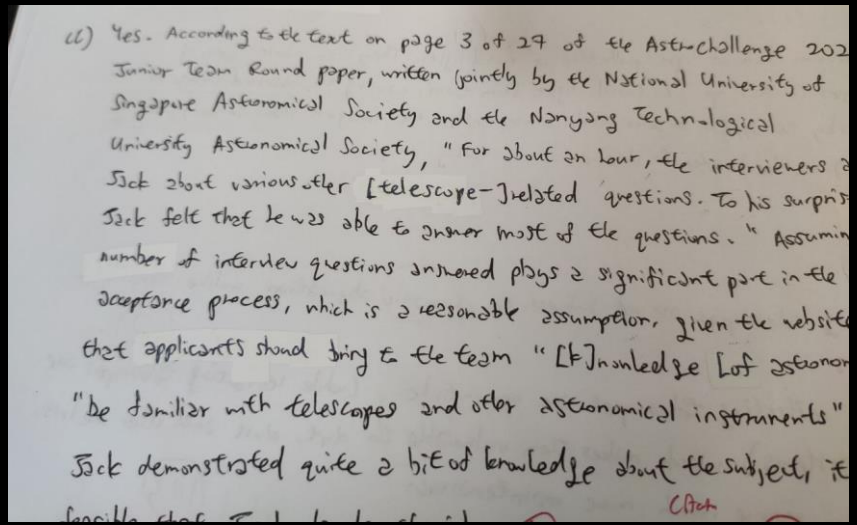
Statistics

Mean: 7.26
Median: 7.5
Hi: 15.5

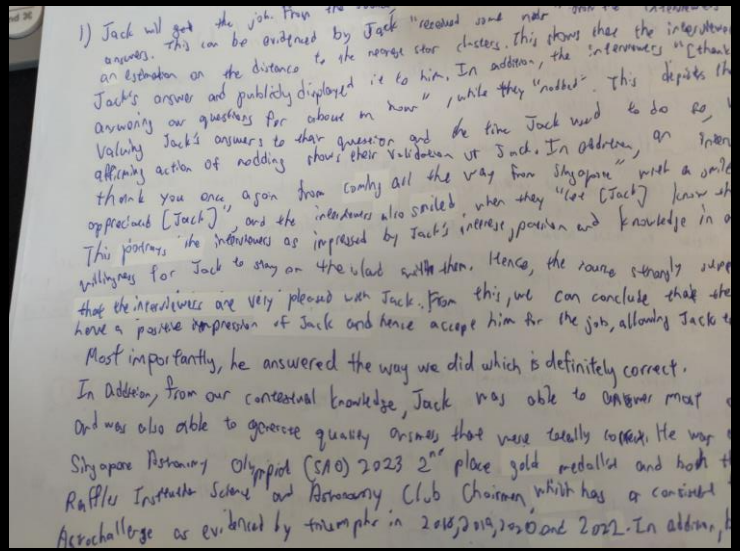


The Interviewers smiled. "That indeed. We will let you know the results soon."

(l) Do you think Jack will get the job? Explain why or why not. [1]



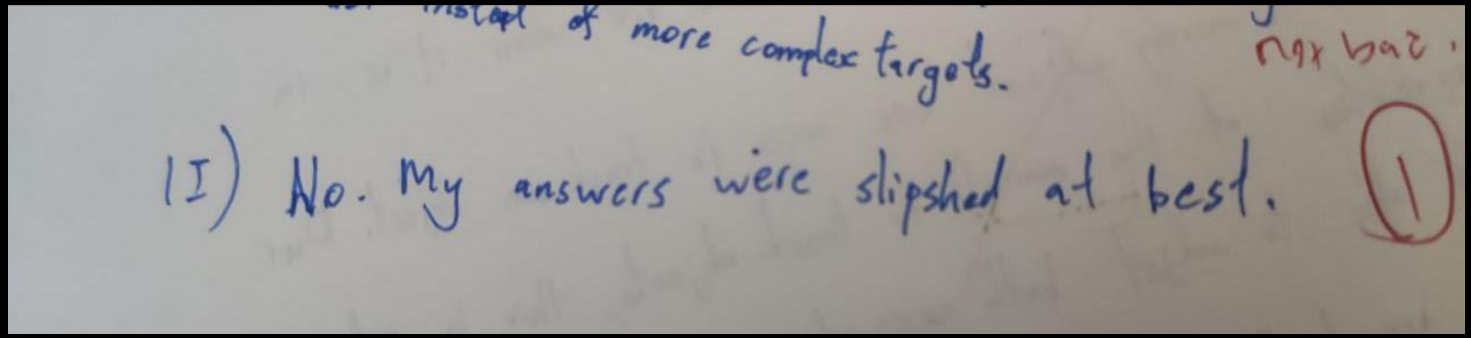
ll) Yes. According to the text on page 3 of 27 of the Astrochallenge 202
Junior Team Round paper, written jointly by the National University of
Singapore Astronomical Society and the Nanyang Technological
University Astronomical Society, "For about an hour, the interviewers
Jack about various other [telescope-]related questions. To his surpri
Jack felt that he was able to answer most of the questions." Assumin
number of interview questions answered plays a significant part in the
acceptance process, which is a reasonable assumption. Given the websit
that applicants should bring to the team "[K]nowledge [of astronom
"Be familiar with telescopes and other astronomical instruments"
Jack demonstrated quite a bit of knowledge about the subject, it

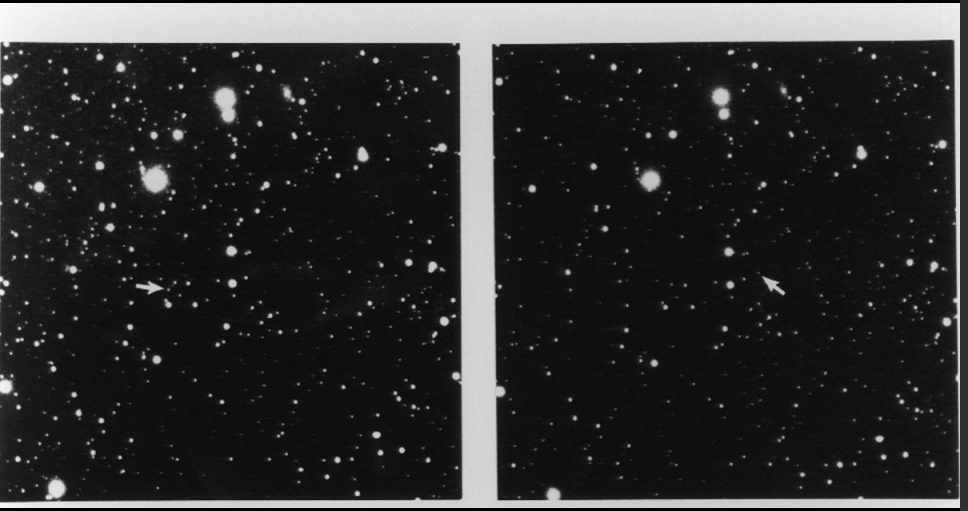


1) Jack will get the job. From the
this can be evidenced by Jack "received sound natur
answers.
an estimation on the distance to the nearest star clusters. This shows that the interviewer
Jack's answer and publicly displayed it to him. In addition, the interviewers "[thank
answering our questions for about an hour", while they "nodded". This depicts th
valuing Jack's answers to their question and the time Jack used to do so.
affirming action of nodding shows their validation of Jack. In addition, an inter
thank you once again from coming all the way from Shyapore" with a smile
appreciate [Jack]", and the interviewers also smiled when they "let [Jack] know th
This portrays the interviewers as impressed by Jack's interest, passion and knowledge in a
willingness for Jack to stay on the island with them. Hence, the source strongly suppo
that the interviewers are very pleased with Jack. From this, we can conclude that the
have a positive impression of Jack and hence accept him for the job, allowing Jack t
Most importantly, he answered the way we did which is definitely correct.
In addition, from our contextual knowledge, Jack was able to answer most
and was also able to generate quality answers that were totally correct. He was
Singapore Astronomy Olympiad (SAO) 2023 2nd place gold medalist and both th
Raffles Institution Science and Astronomy Club Chairman which has a consistent
Astrochallenge as evidenced by triumphs in 2018, 2019, 2020 and 2022. In addition,

How are participants finding the time to write long essays for a free mark question???

An equally valid way to get your free marks





Q2

Asteroid-Centered Direct Redirection Quest

Brendan

Overall Intent

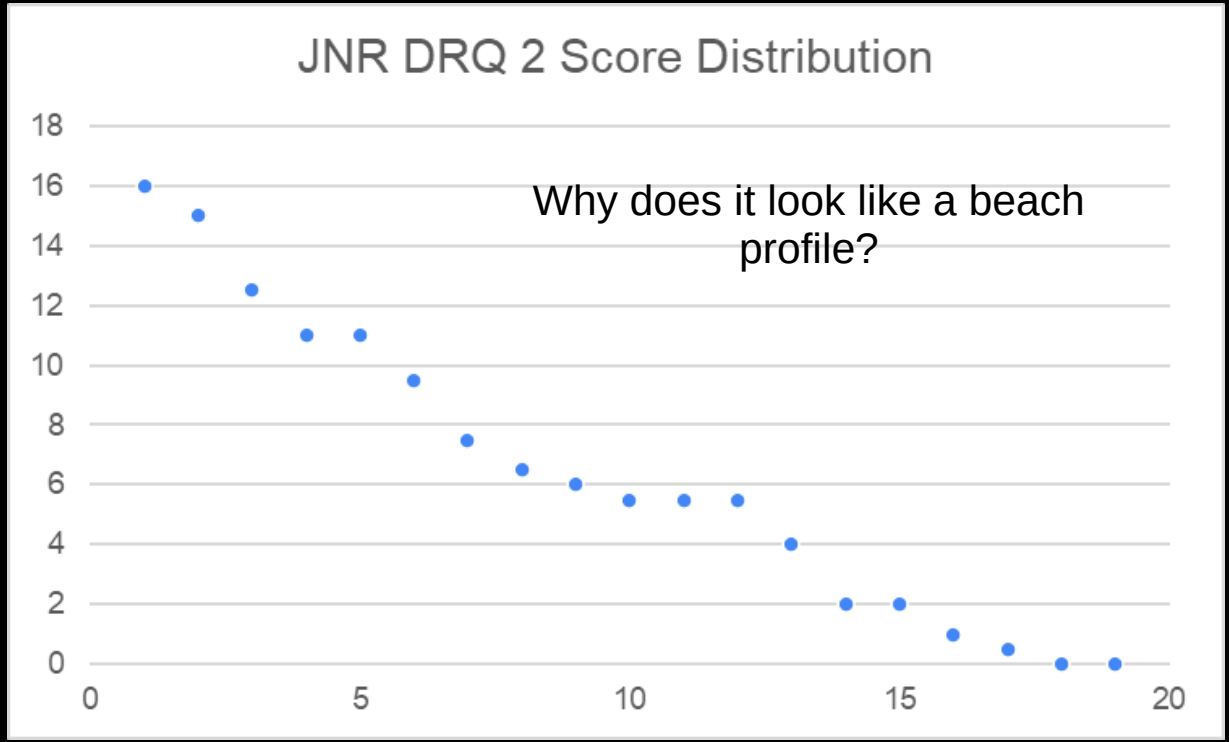
- Introduction to popular Asteroid Redirection techniques
- Spans multiple topics in Astrophysics
  - More heavy on Celestial Mechanics
    - Orbital Transfers
    - Orbital Parameters
    - Momentum Conservation
  - Touches slightly on Stellar Physics
    - Momentum of Light

Statistics

Mean: 6.37

Median: 5.5

Hi: 16



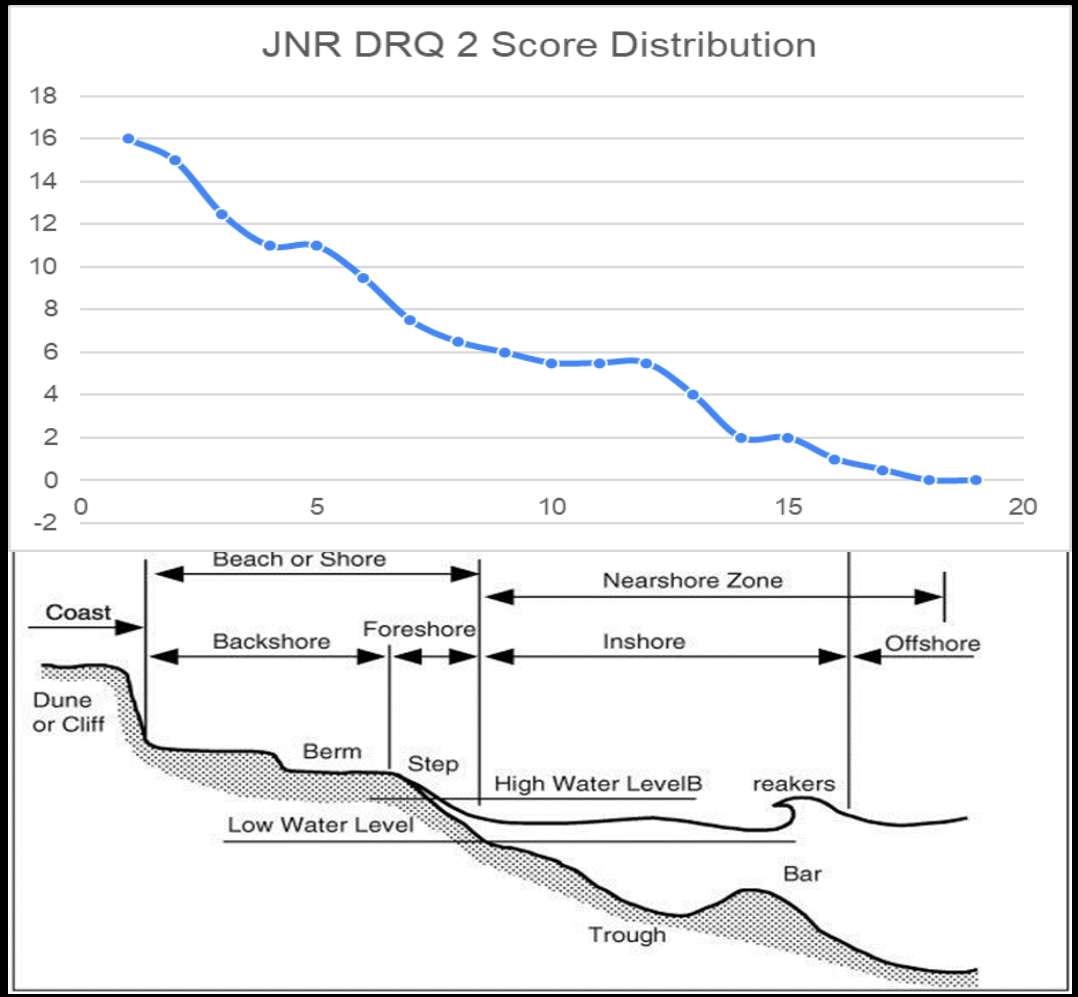
Statistics

Removing NIL Attempts

Mean: 7.12

Median: 6

Hi: 16



Summary

- Most got the “give-away” questions
- Only a few attempted the harder questions
- Most saw the integral and then panicked.

(j)

I know calc. but I can't integrate.

Me when I see ∫.

(k)

I'm too lazy to show.

You don't have to integrate.

$$\Delta p = \int_{-\pi/2}^{\pi/2}\int_{-\pi/2}^{\pi/2} p_\gamma(1+\cos 2\theta\cos 2\psi)d\theta d\psi$$

$$= p_\gamma \pi^2$$

(c).

~~—~~ I have no idea :(

Next time, just write something.

Not Reading the Question

What was “U”?

$$\Delta V \approx -\frac{2Mu}{M}$$

$$V \approx -\frac{2(1000\text{kg})(u = 1.660539 \times 10^{-27}\ \text{kg})}{2 \times 10^{13}\ \text{kg}}$$

Whot?!

Atomic mass unit $u = 1.660539 \times 10^{-27}$ kg

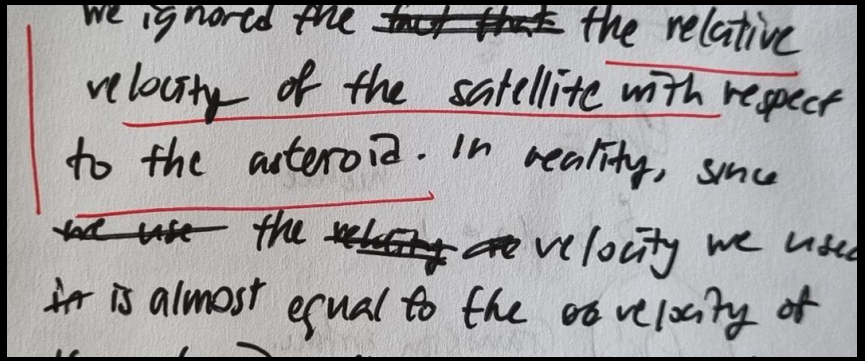
m and M are the masses of the probe and the asteroid respectively, with u being the orbital velocity of the probe with respect to the Sun at the point of impact.

Not Reading the Question

as a single entity. We can then show that the change in the asteroid's velocity is roughly given by:

$$\Delta V \approx -\frac{2mu}{M} \tag{3}$$

What was "U" again?



Clarification

You might be wondering where the negative sign came from.

A sneak peek into an older draft…

For convention, we will use m and M as the masses of *Messiah* and Alvarez respectively, with u being the orbital velocity of *Messiah* with respect to the Sun at the point of impact.

Then, it is a matter of applying the conservation of angular momentum:

$$m(-u)r + Mur = (M+m)(u+\Delta V)r$$

We can simplify by cancelling like terms and get:

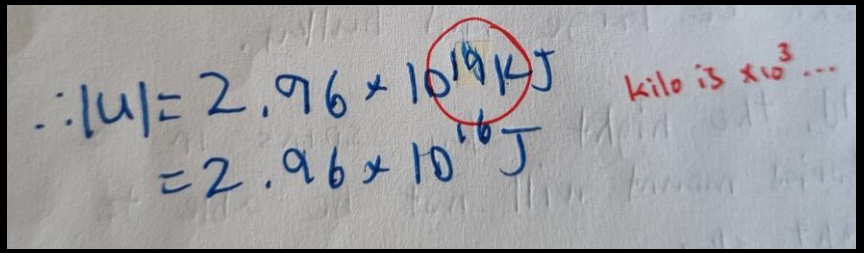
$$-2mu = (M+m)\Delta V$$

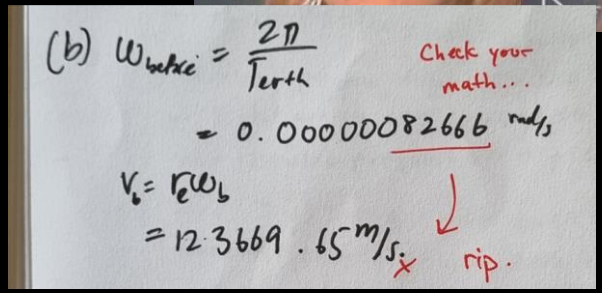
from which we get our desired result by taking that $m << M$:

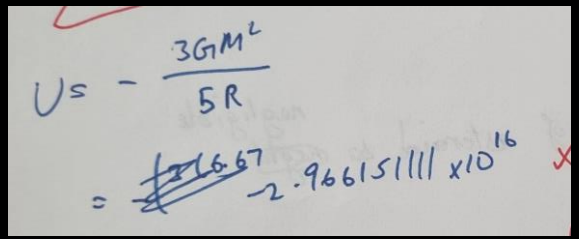
$$\Delta V = \frac{-2mu}{M+m} \approx \frac{-2mu}{M}$$

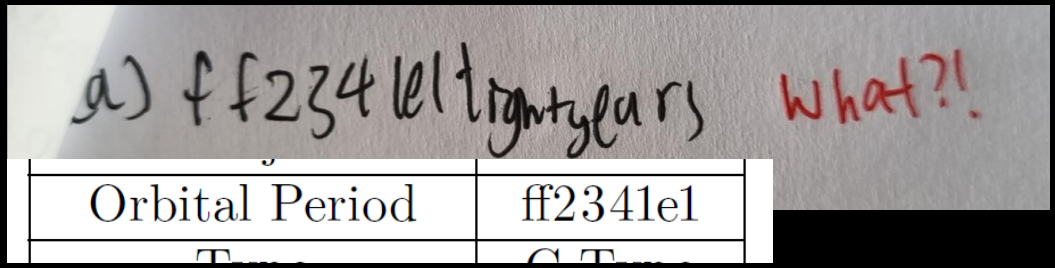
Math Errors

Random Math Errors



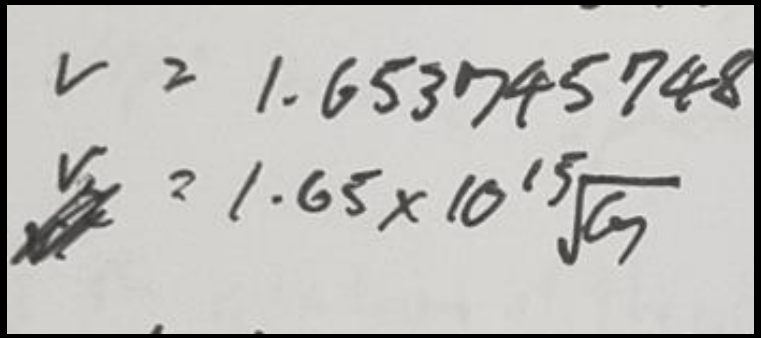






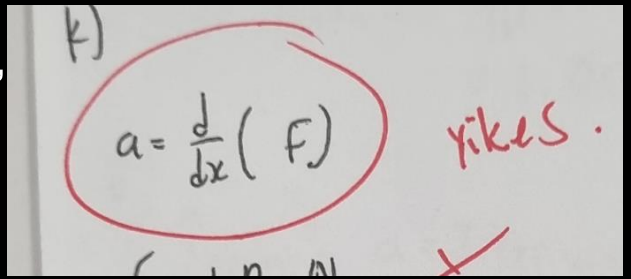
Physics Errors

Forgetting what “G” is



GG

Putting the NEW in NEWton’ Law

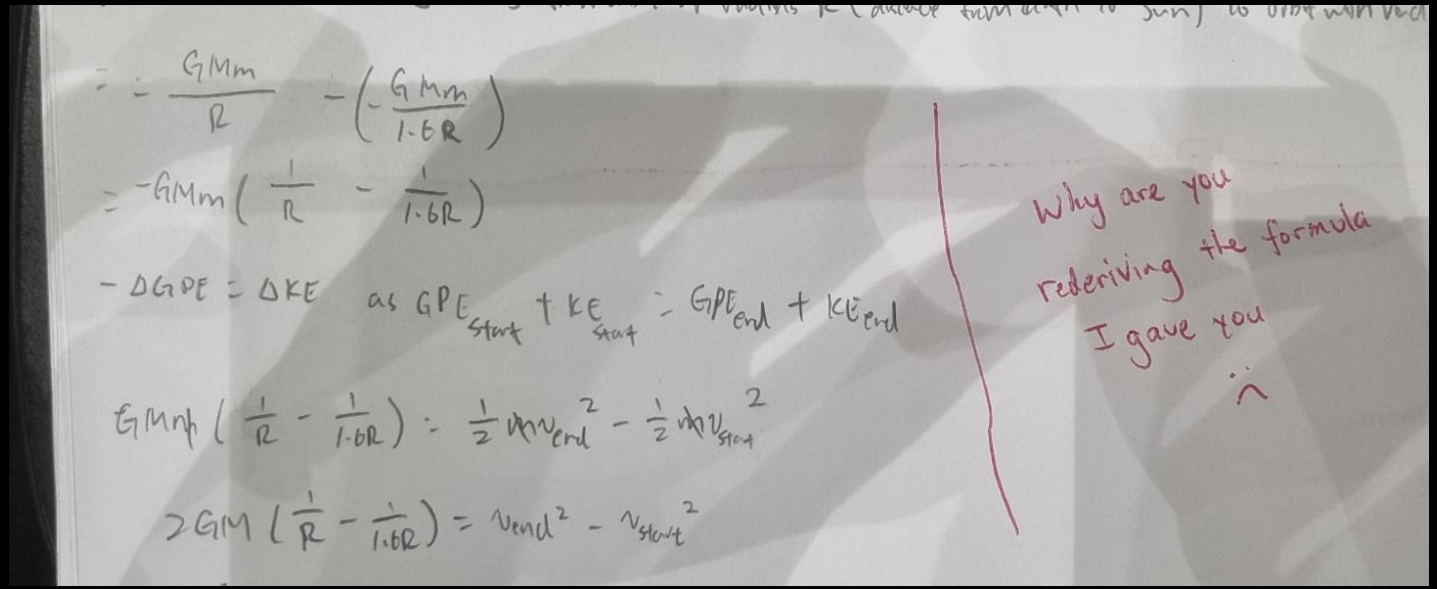


Part (B)

$$v^2 = GM\left(\frac{2}{r} - \frac{1}{a}\right) \qquad (1)$$

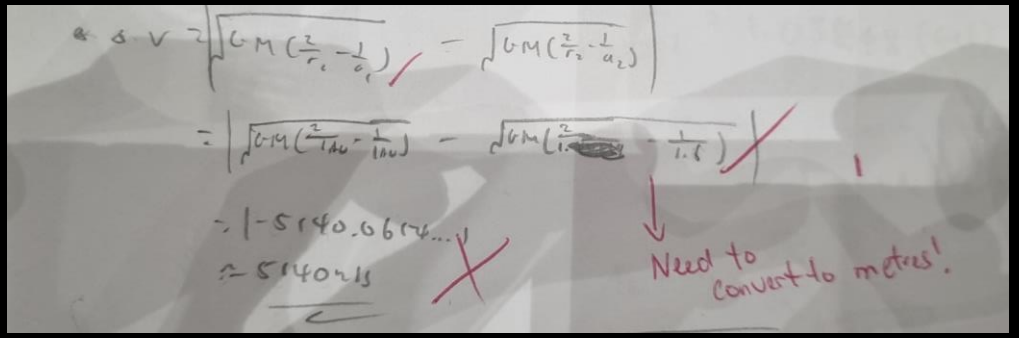
(b) Calculate the $|\Delta v|$ needed to change the probe's orbit. **[3]**

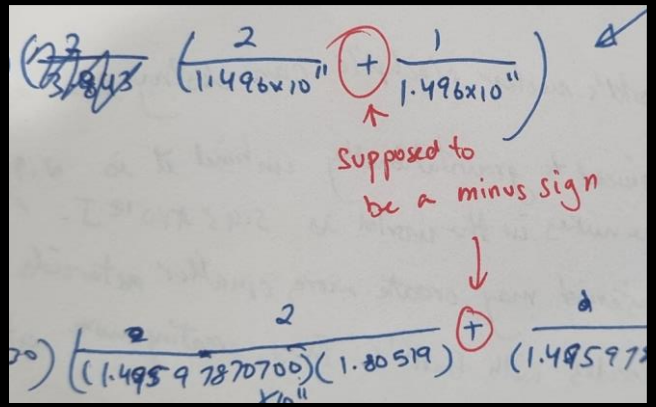
"Rederiving" the Vis-Viva equation

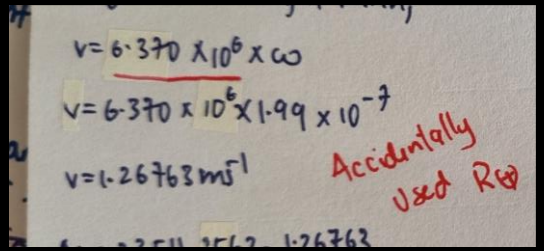


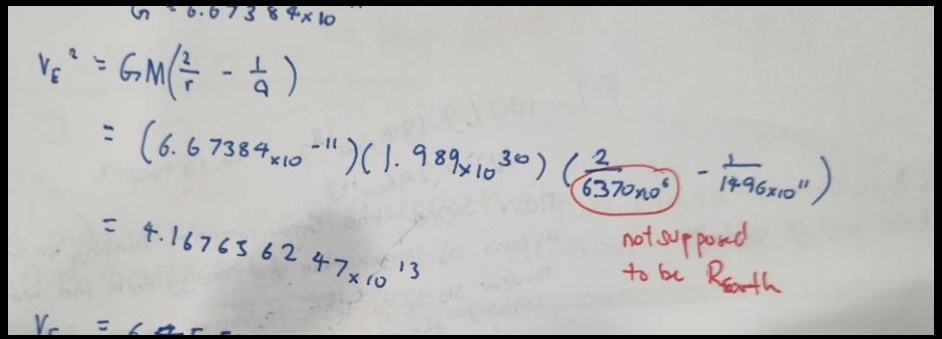
Part (B)

Using the Vis-Viva Wrongly



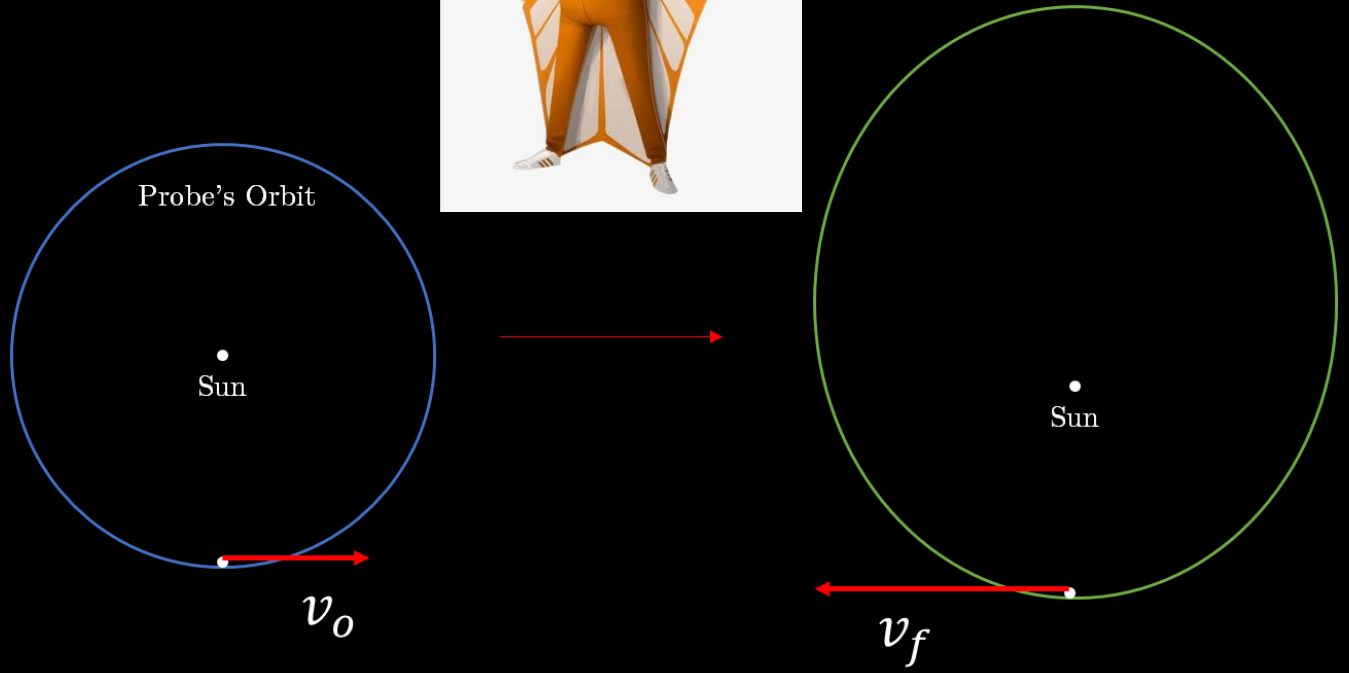






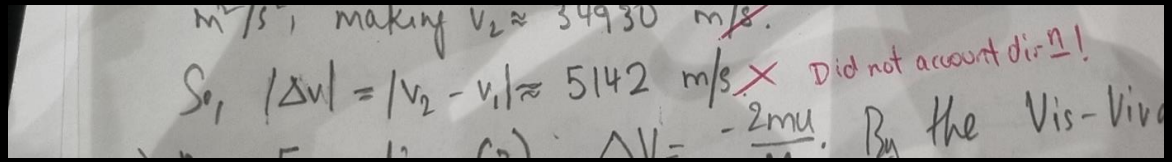
Part (B)

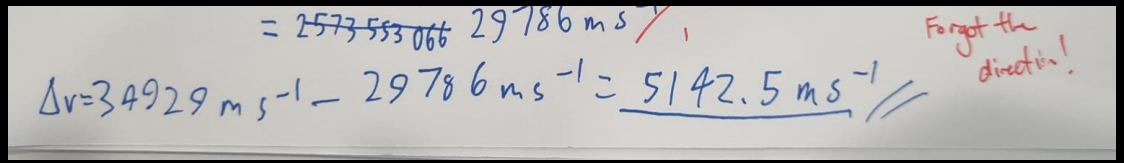
What is a Vector?

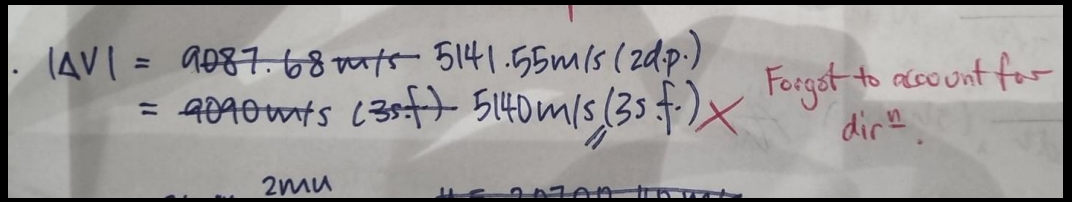


Part (B)

Forgetting to account for direction.







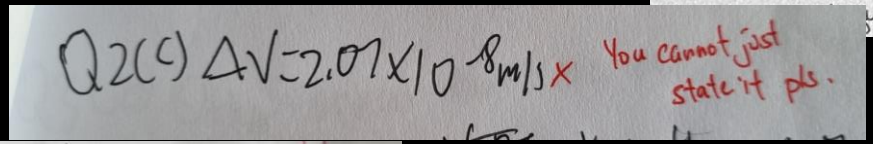
Part (C)

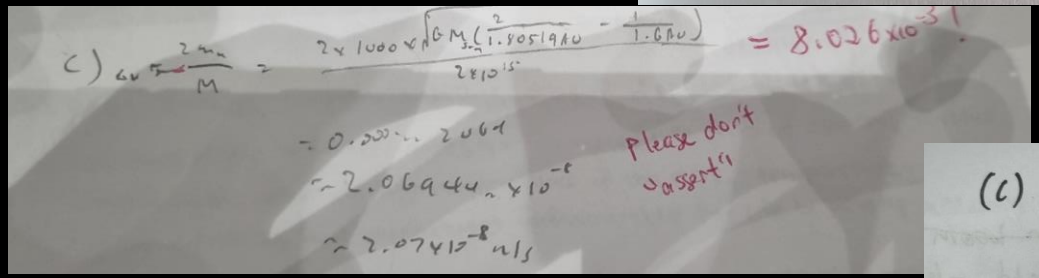
(c) **For a medium-sized probe of $m = 1000kg$ and using the mass of the asteroid as 2×10^{15}kg, show that the change in velocity is $\Delta V = 2.07 \times 10^{-8}$m/s.** [2]

"assumptions

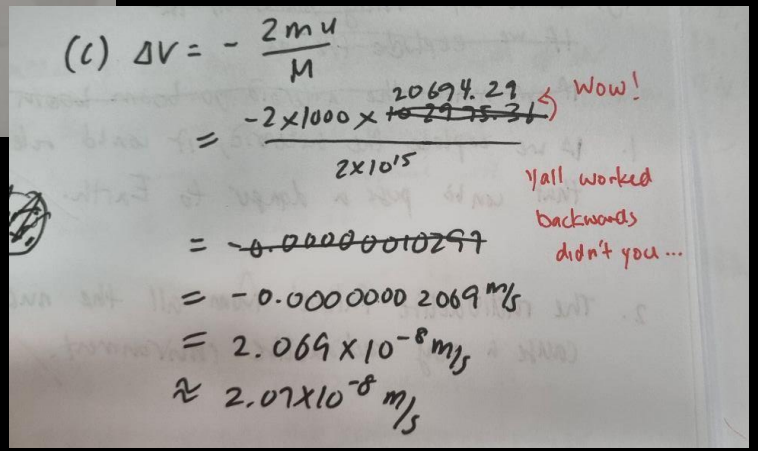
relationships."

"Proof by Assertion"





"Proof by Working Backwards"



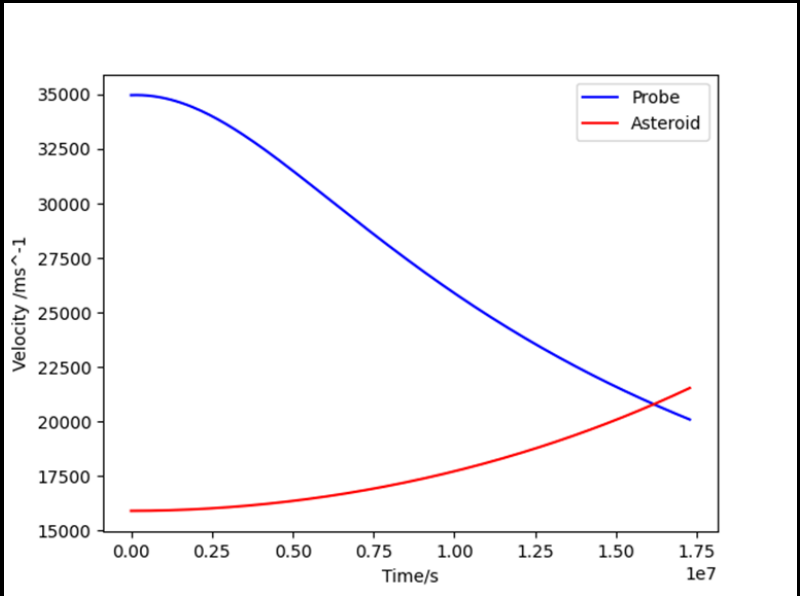
Part (D)

(d) Which assumption did we make in our analysis that caused such a underestimation in our theoretical prediction? [2]

```
while t < fraction*T:
    xdotA = vA[i][0]
```

Some argued that gravitational effects will increase the impact

So if we were to account for it and simulate it:




```
# Get the difference positional vector
dx = xP - xA
dy = yP - yA
thetaD = math.atan2(dy, dx)

# Get the respective forces
FA = -attraction(M_Alvarez, M_SUN, norm(xA, yA))
FP = -attraction(M_Probe, M_SUN, norm(xP, yP))
FCross = attraction(M_Alvarez, M_Probe, norm(dx, dy))
```

$$v_f = 20787\ \mathrm{ms}^{-1}$$

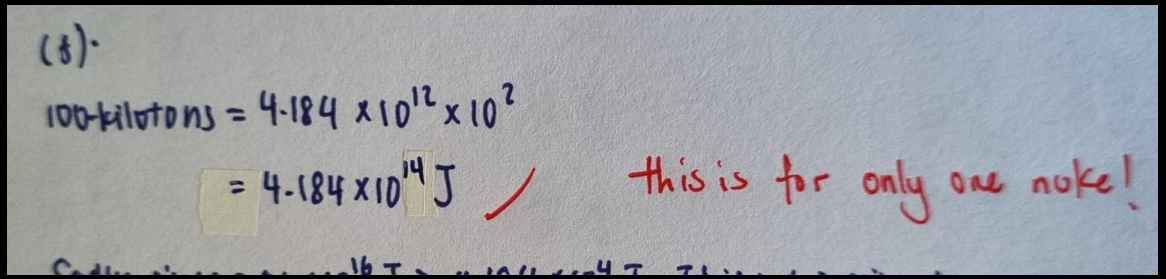
This constitutes a 0.5% increase in velocity.

Part (F)

(f) **Given the worlds' current nuclear stockpile, is it enough to gravitationally unbind the asteroid in one singular (spectacular) blast?** [2]

How many nukes do we have?

We have a lot of nuclear weapons in the world. As of early-2023, the world has around 13000 nukes[?].



Part (G)

If you had been paying close attention…

(g) List two other possible (physical) pitfalls with this plan of using nukes, or other high-yield explosives, in saving the Earth from the asteroid impact.

← You'd have seen this

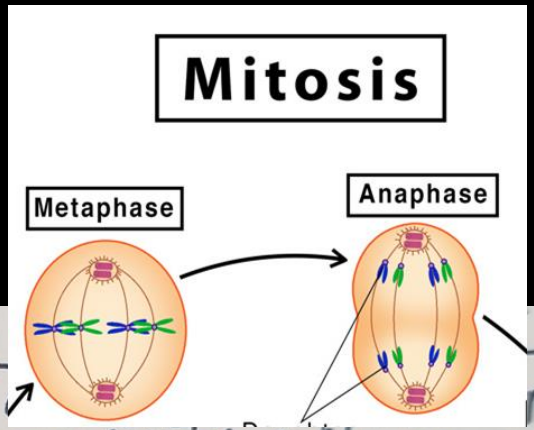
…and this line v

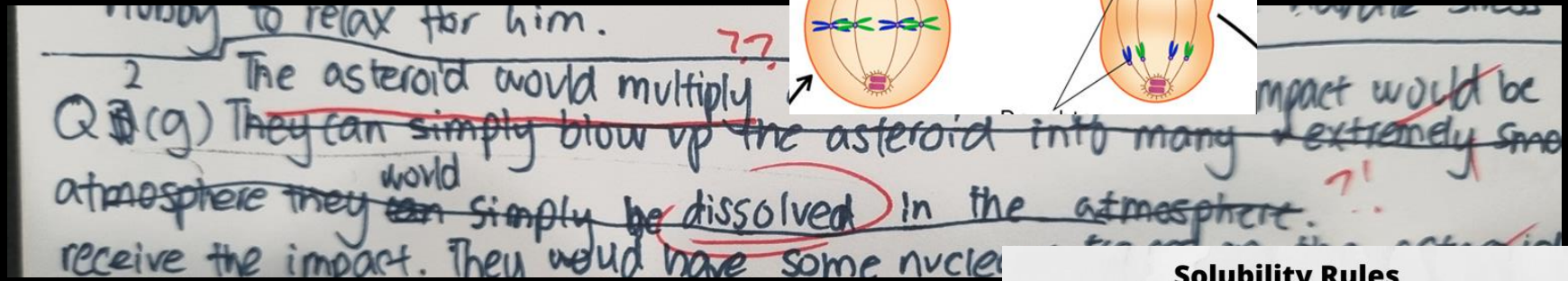
To blow it up, we need to add energy into the asteroid to overcome the gravitational forces holding it together. Well, technically, we also need to break the rock by overcoming the rock's elastic properties but

Free 2 marks! Average was 0.895…

Part (G)

Still…





Solubility Rules
Mnemonic Tricks

Always Soluble NAG SAG	Exceptions PMS and Castro Bear
Nitrates (NO_3^-)	**P** (Pb^{2+}, lead)
Acetates ($C_2H_3O_2^-$)	**M** (mercury, Hg^{2+})
Group 1 (Li^+, Na^+ etc.)	**S** (silver, Ag^+)
Sulfates (SO_4^{2-})	**Ca** $^{2+}$
Ammonium (NH_4^+)	**Sr** $^{2+}$
Group 17 (F^-, Cl^- etc.)	**Ba** $^{2+}$

Q3

Exoplanets and Exo-Life

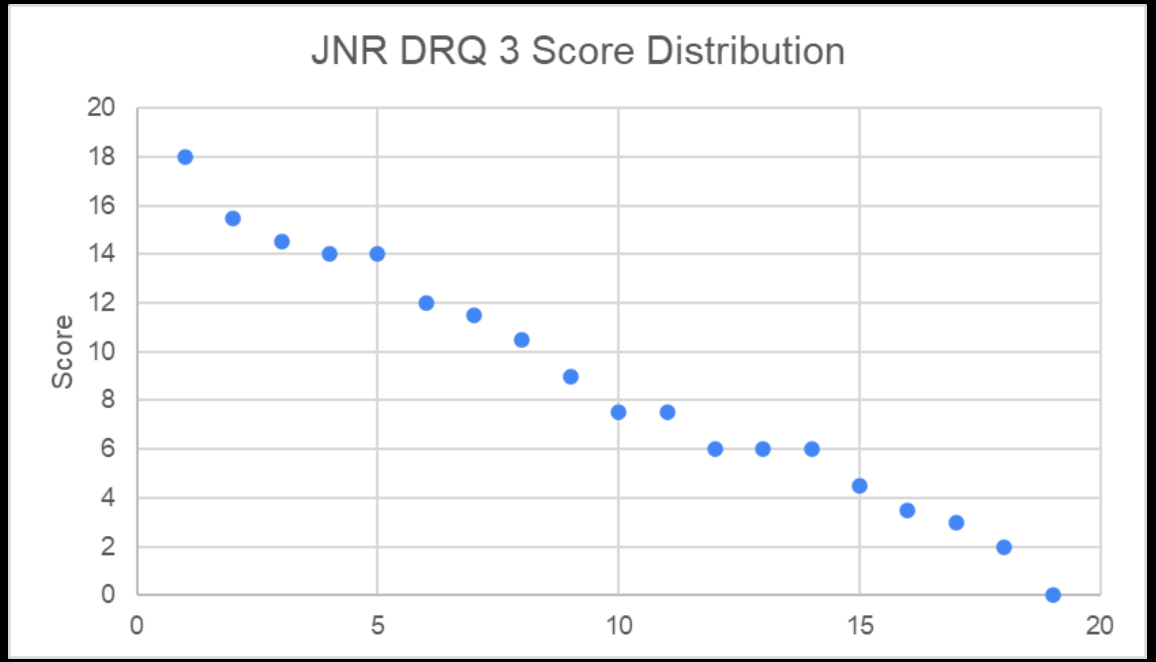
Choon Hean

Statistics

Mean: 8.68

Median: 7.5

Hi: 18

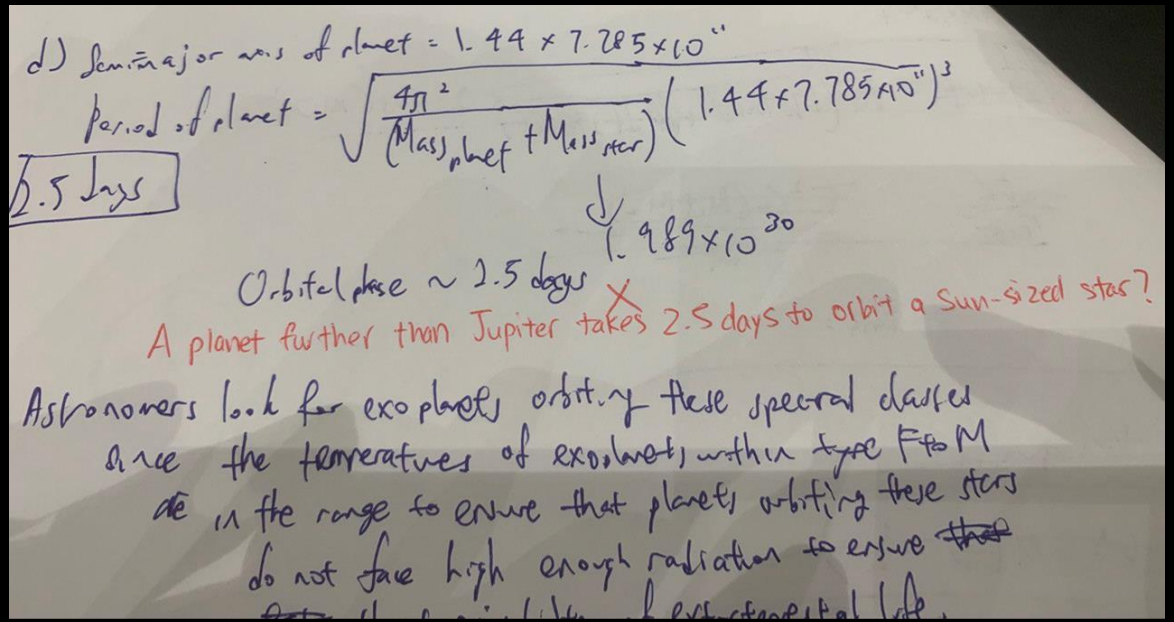


Summary

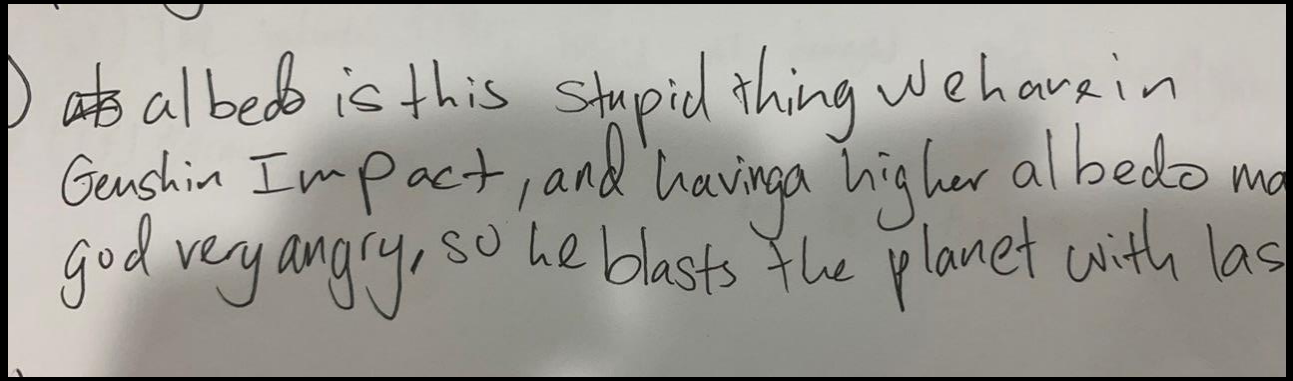
- Test some concepts in exoplanet discovery/spectroscopy
- Some calculations with given formulae

- Relatively well-done overall (compared to the rest of the questions)
- Some careless mistakes in calculations :(
    - Remember to check your work!

Unfortunate Miscalculations



When you give up

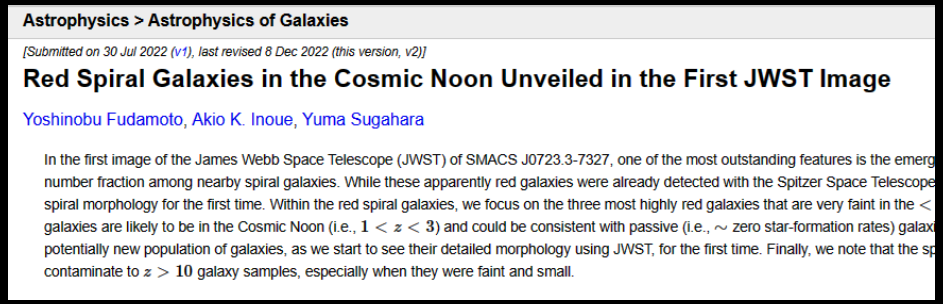


Q4

Red Spiral Galaxies at High Noon

Janani, Frederik, Ken Rui

Rationale



Astrophysics > Astrophysics of Galaxies

[Submitted on 30 Jul 2022 (v1), last revised 8 Dec 2022 (this version, v2)]

Red Spiral Galaxies in the Cosmic Noon Unveiled in the First JWST Image

Yoshinobu Fudamoto, Akio K. Inoue, Yuma Sugahara

In the first image of the James Webb Space Telescope (JWST) of SMACS J0723.3-7327, one of the most outstanding features is the emerg
number fraction among nearby spiral galaxies. While these apparently red galaxies were already detected with the Spitzer Space Telescope
spiral morphology for the first time. Within the red spiral galaxies, we focus on the three most highly red galaxies that are very faint in the <
galaxies are likely to be in the Cosmic Noon (i.e., $1 < z < 3$) and could be consistent with passive (i.e., $\sim$ zero star-formation rates) galax
potentially new population of galaxies, as we start to see their detailed morphology using JWST, for the first time. Finally, we note that the sp
contaminate to $z > 10$ galaxy samples, especially when they were faint and small.

- Introduce a recent JWST research paper result
- Guide participants through understanding the methods of the paper, the results, and its implications
- Test conceptual understanding of star formation, galaxies, and spectroscopy

- As a result, question has long background explanatory text
  - Surely people know how to read, right?

QM Postmortem (Errata)

- JWST orbits at L2 (true fact)
- But diagram shows L2 between Earth and the Sun
- What does this mean?

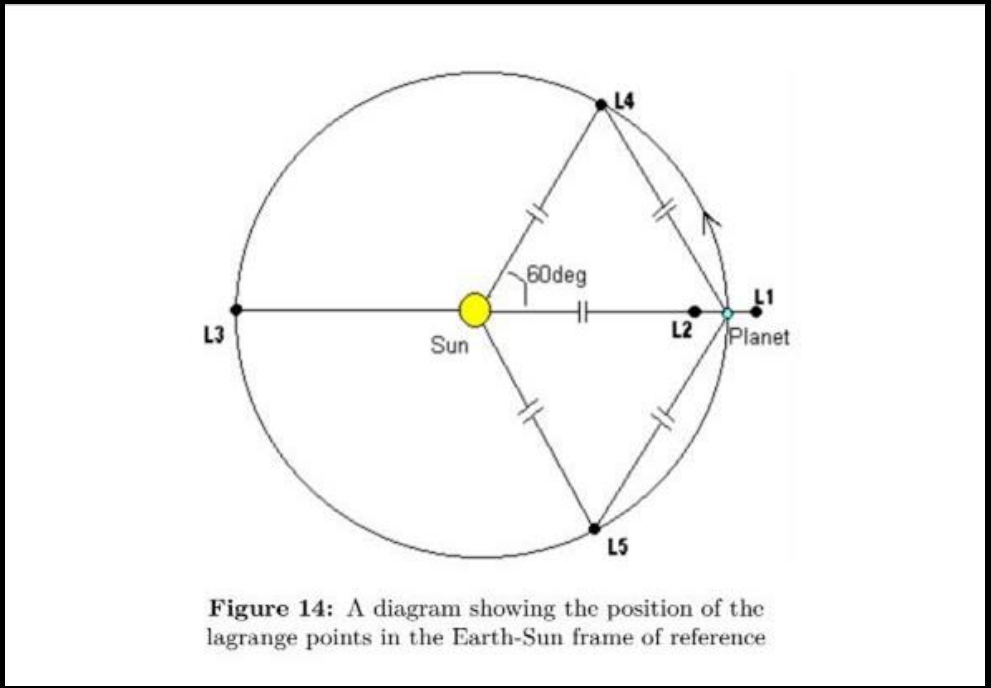


Figure 14: A diagram showing the position of the lagrange points in the Earth-Sun frame of reference

JWST, SOHO’s successor

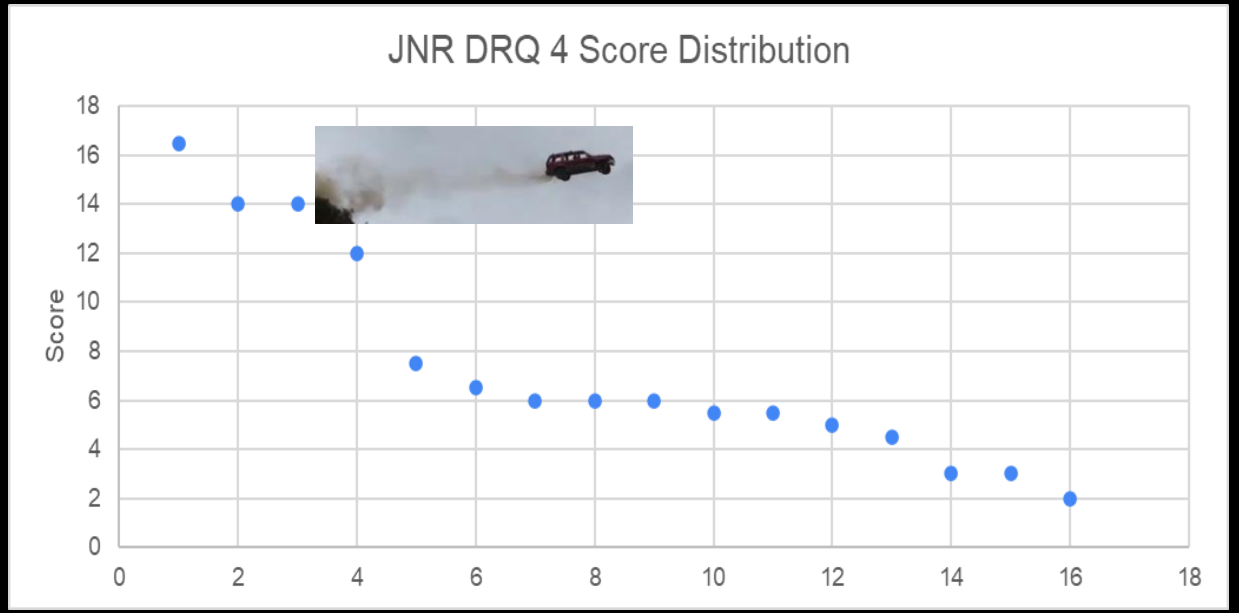
- Nobody raised this up during the DRQ btw
- Full marks given for calculations based on diagram instead of the actual L2 point
- Lesson Learnt: Don’t trust everything you find on google

Statistics

Mean: 6.16

Median: 5.5

Hi: 16.5

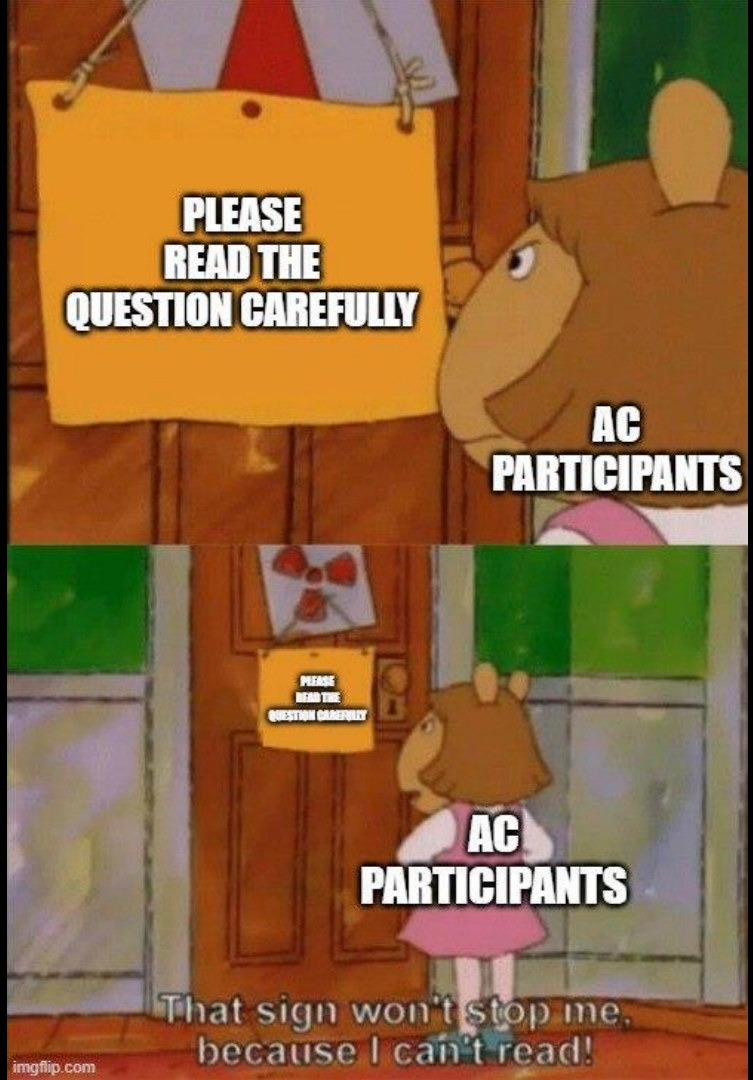


Summary

1. Many appear shocked by the amount of graphs when checking the paper
    a. Some realised afterwards that it is actually mostly conceptual questions (graphs are your friend!)

1. I get the impression that you are skipping all the explanatory text the QMs spent hours writing ;_;

Seems to be a persistent theme throughout the DRQ round



Surely people will read the text before the question?

When we observe the spectra of elliptical galaxies such as in Figure 16, we find that they tend to not exhibit strong emission lines like in most spiral galaxies. Instead, we mostly see the 'reverse'; strong characteristic dips corresponding to known elements which can also be used to measure redshift. To understand this, it might be helpful to recall how the spectrum of a star looks like (Figure 17).

(d) Explain how are the absorption lines of a galactic spectra mainly produced. [1]

Starlight has distinct absorption lines!! ->

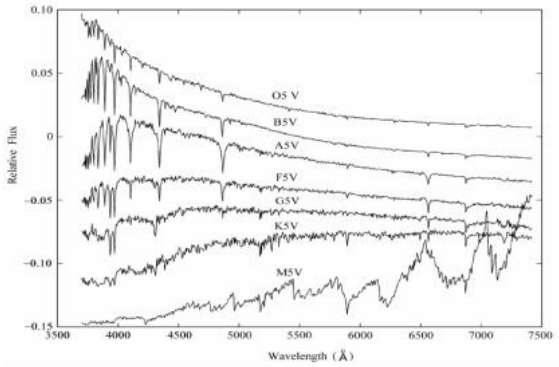
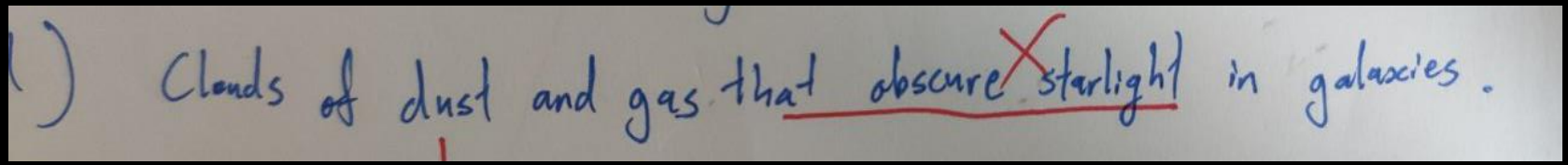
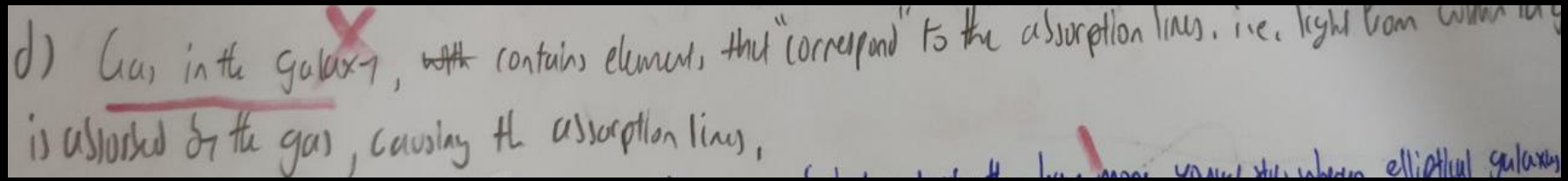
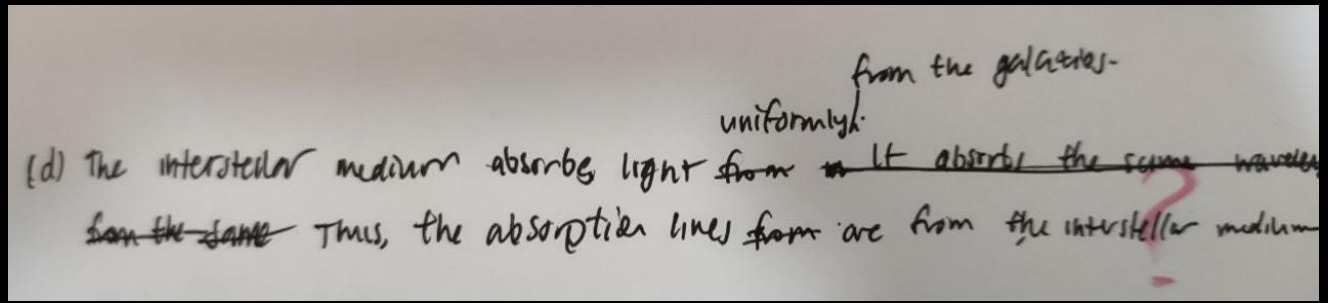


Figure 17: Examples of typical stellar spectra labeled by their Harvard spectral classification.

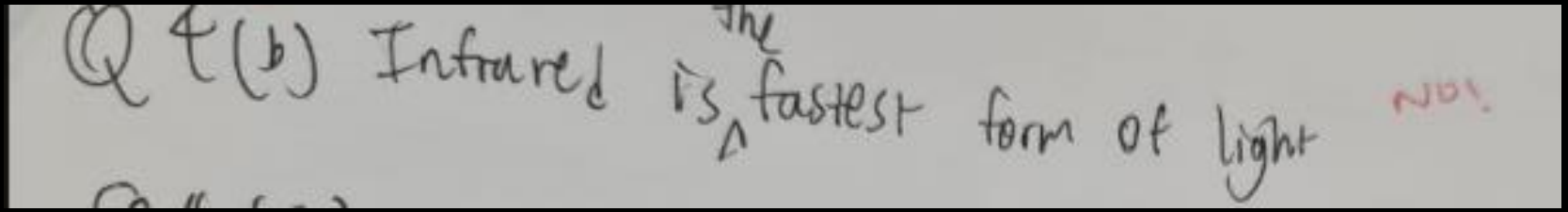
An unfortunately common answer







It is called “speed of light” for a reason…



Another casualty of poor reading comprehension…

(i) **Based on what was discussed thus far, state the 3 factors that could plausibly explain the red appearance of the JWST galaxies. These factors need to be accounted for or be included as parameters in the model fitting process.** [3]

Solution:

1) Redshift 2) Presence of dust 3) Old stellar population

All of these factors were painstakingly introduced and explained as you progress throughout this question!

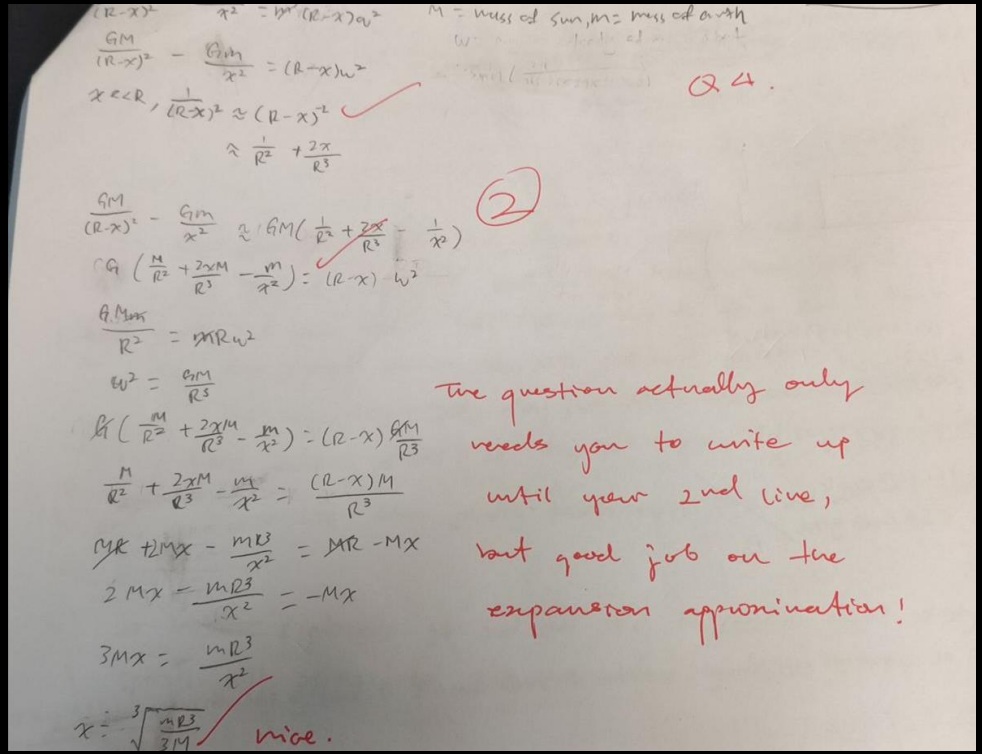
(a) Given the information above, derive an equation on how we can find the distance between Earth and JWST. You do not need to make numerical calculations nor provide a neat RHS equation (i.e., r = f(x,y,z)) [2]

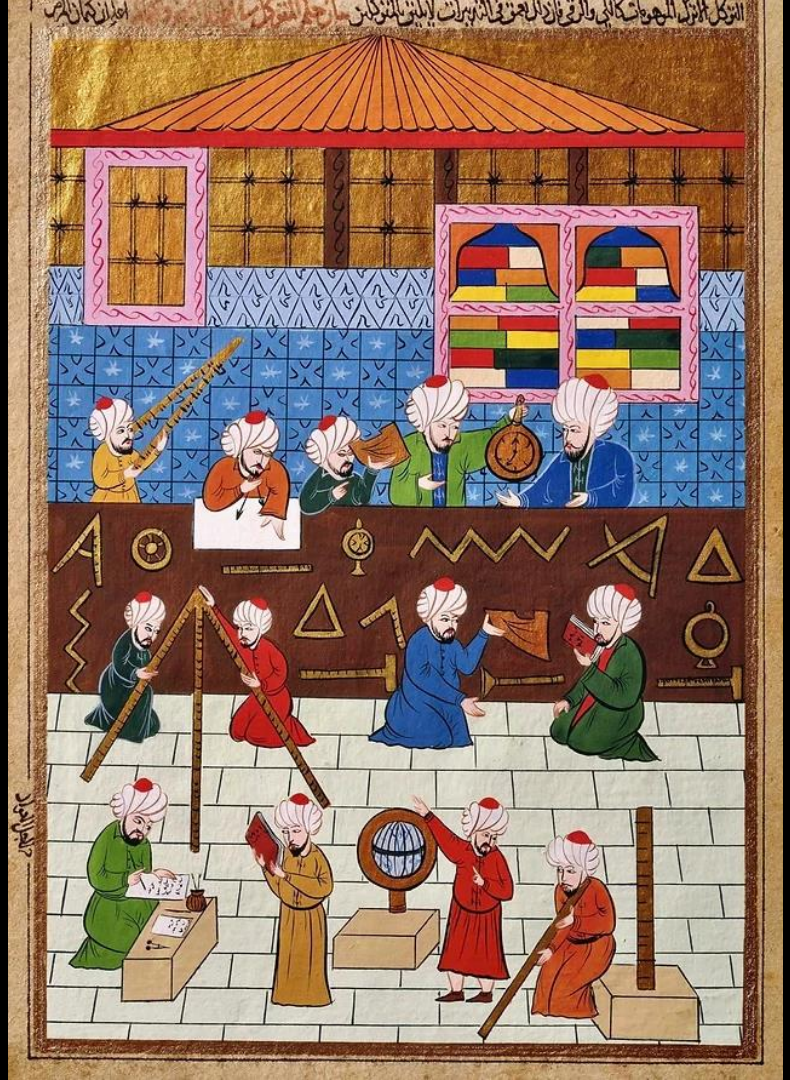
Exemplary Answer

Correct binomial expansion and approximation for L2 distance in terms of m, M and R_earth

No extra credit though :(

This is actually why we only require you to write the correct equality without solving





Q5

Arabic Astronomy

Kia Yee

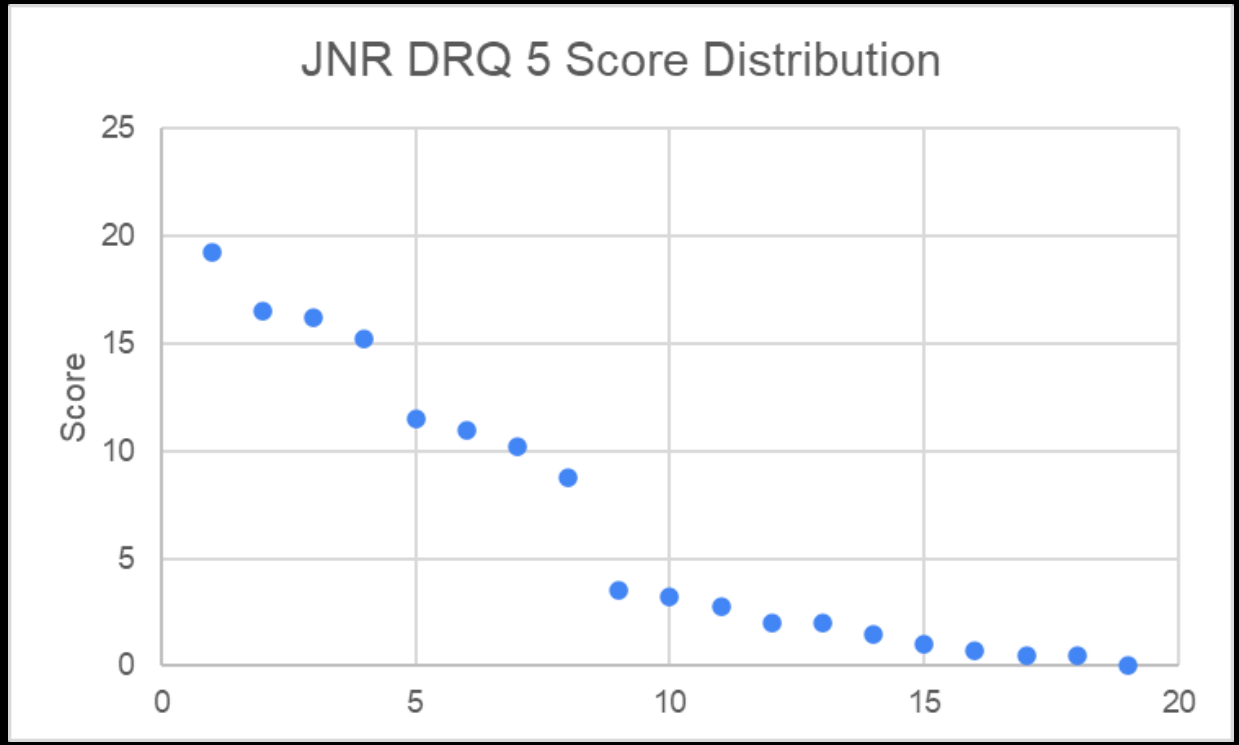
Statistics

Removing NIL Attempts

Mean: 6.66

Median: 3.25

Hi: 19.25

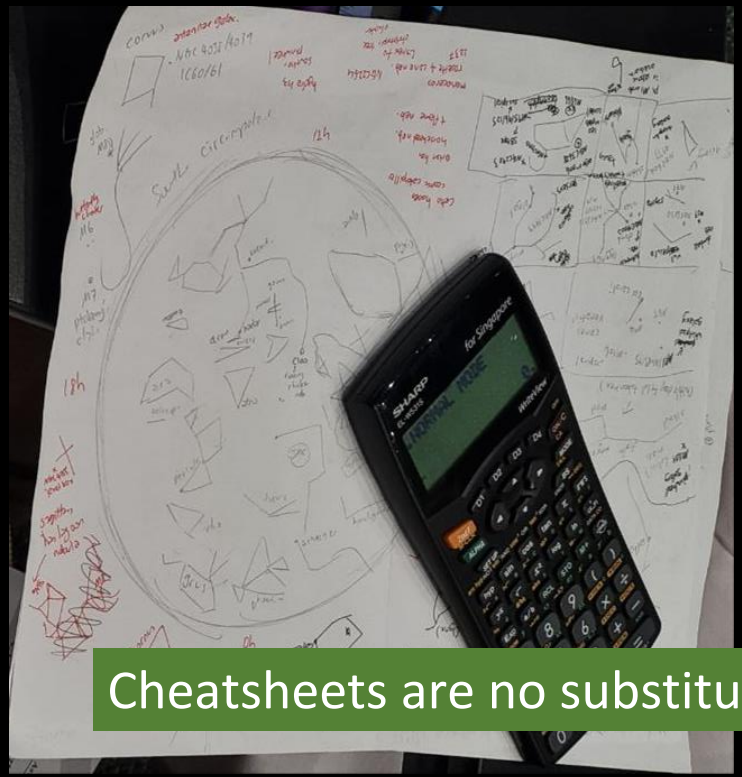


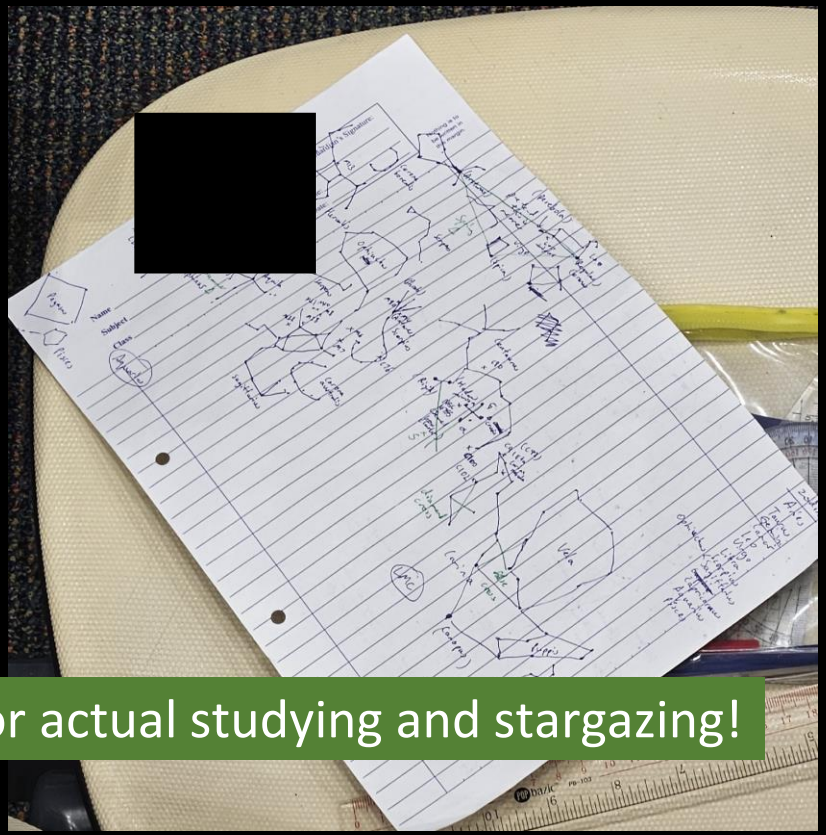
Overall comments

- Performance for this question was highly varied
  - Average score for this question was **6.66** marks, which lies in the middle of the Junior Team round Questions
  - However, this question had a median of only **3.25** marks, which is the lowest median among all Junior Team Round Questions.

- My guess is that many teams were shocked by all the Arabic names and unfamiliar constellations that appeared...
  - Many of our modern star names however are transliterations of these Arabic names, so reading those names out aloud would probably have clued you in to the answer.

The best scoring teams came well prepared…

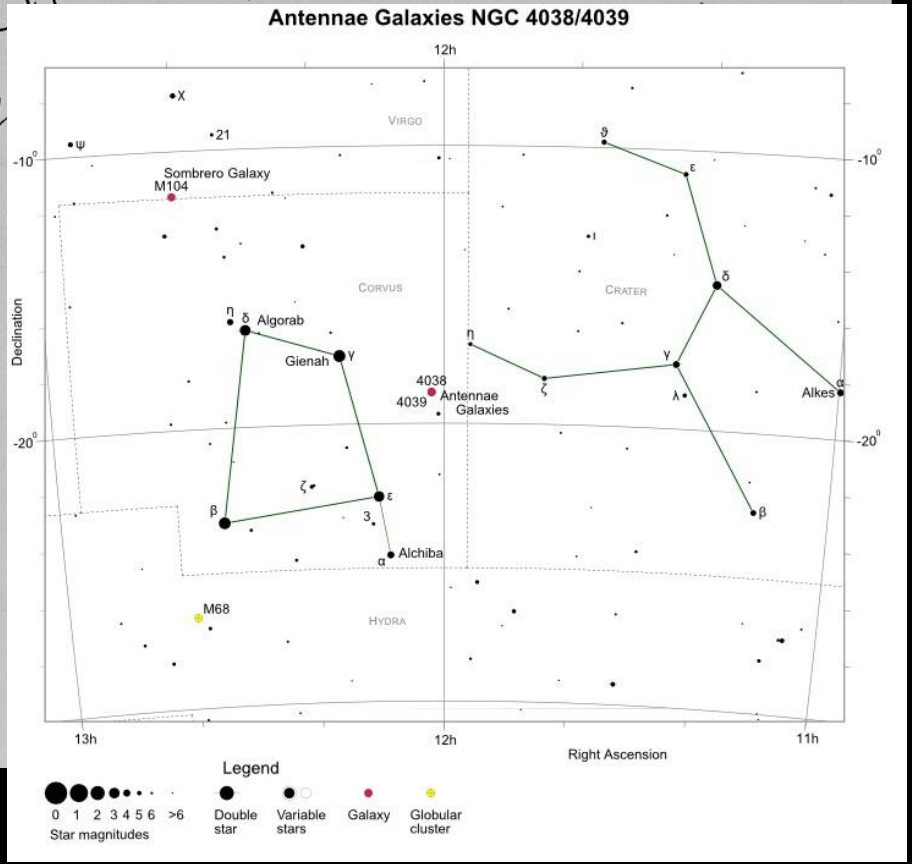




Cheatsheets are no substitute for actual studying and stargazing!

Case in point

- Out of this team's perfect star chart analysis was this errant marking.
- I thought this couldn't possibly be correct so I went to check it up.
- Thank you NYGH1 for educating me about the Antennae Galaxies!



Some interesting attempts

Thank you for trying :D

What “camels” could Aldebaran be herding?

- Idea of the question: what objects could stargazers in the 8th Century observe?

f) Orion nebula. ??

f) Pillars of creation ?!?

Please read instructions

- Part VI states that you were supposed to attempt it on the next page

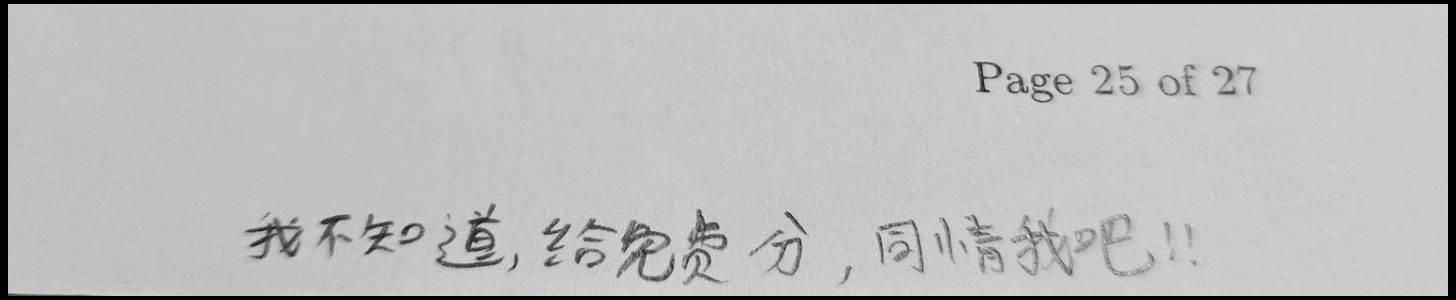
Part VI Star Chart Analysis

A 1-page sized replica of Figure 23 is attached on the next page. You are to mark your answers on the image directly. Remember to detach the page and staple it to your answer script as part of your submission.

- A team however decided to attempt it on the wrong page…

Please read instructions

- Clearly the team realized their mistake at the last moment, because someone wrote this…



Translation: I didn't know, please give me free marks and pity me!!

- Marker's first thought : Saya tak tahu cina?!?

Translation: I don't know Chinese?!?

Please read instructions

- Out of kindness, the marker did try to see if any marks could be awarded
  - Thank you for the attempt at drawing a Big Dipper

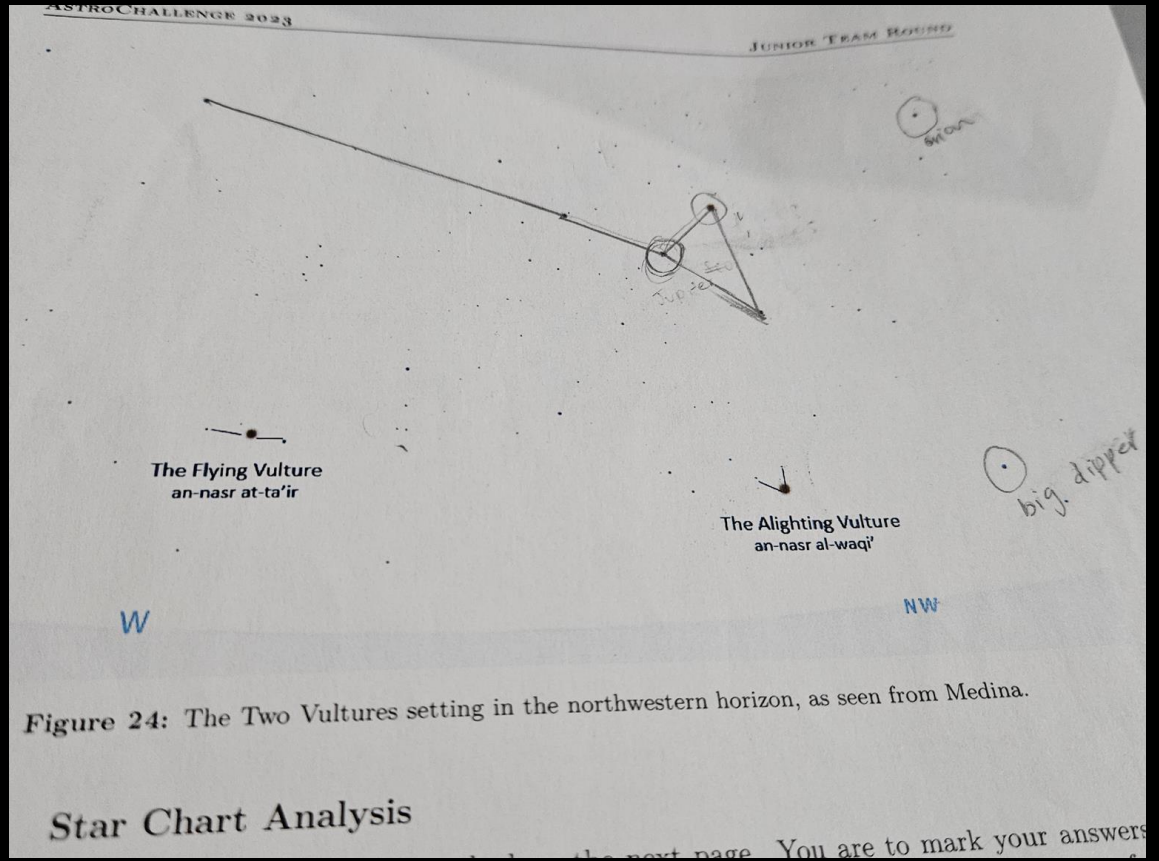


Figure 24: The Two Vultures setting in the northwestern horizon, as seen from Medina.

Star Chart Analysis

... the next page. You are to mark your answers

Moral of the story

世界上没有免费的东西…

Translation: There are no free things in this world…

More seriously:
do read instructions!

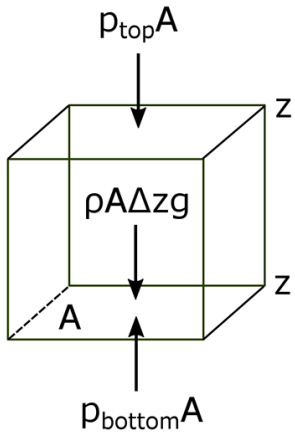
Thanks for trying, and I hope you learnt something from this question!

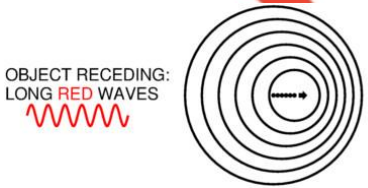
5.2 Senior DRQ

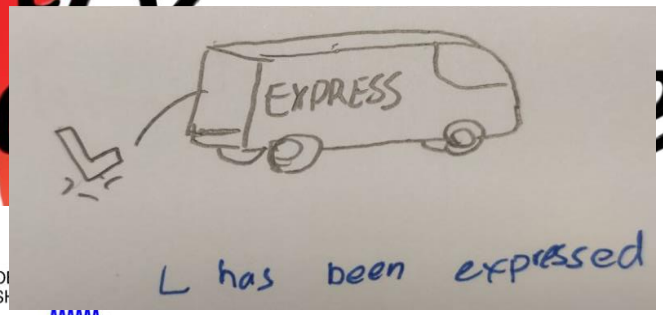
~~5.2 Senior DRQ~~

AC Trauma Support Network

Astro


$p_{top}A$
z+Δz
ρAΔzg
z
A
$p_{bottom}A$


OBJECT RECEDING:
LONG RED WAVES


EXPRESS
L has been expressed


LIVE TUCKER REACTION

How to fumble the bag 101

1. See unfamiliar* topics
2. mfw not written on your cheat sheet
3. TRY NOT TO PANIC!
4. …
5. Start laughing like a maniac in the middle of the LT

*Note: unfamiliar doesn’t always mean difficult!

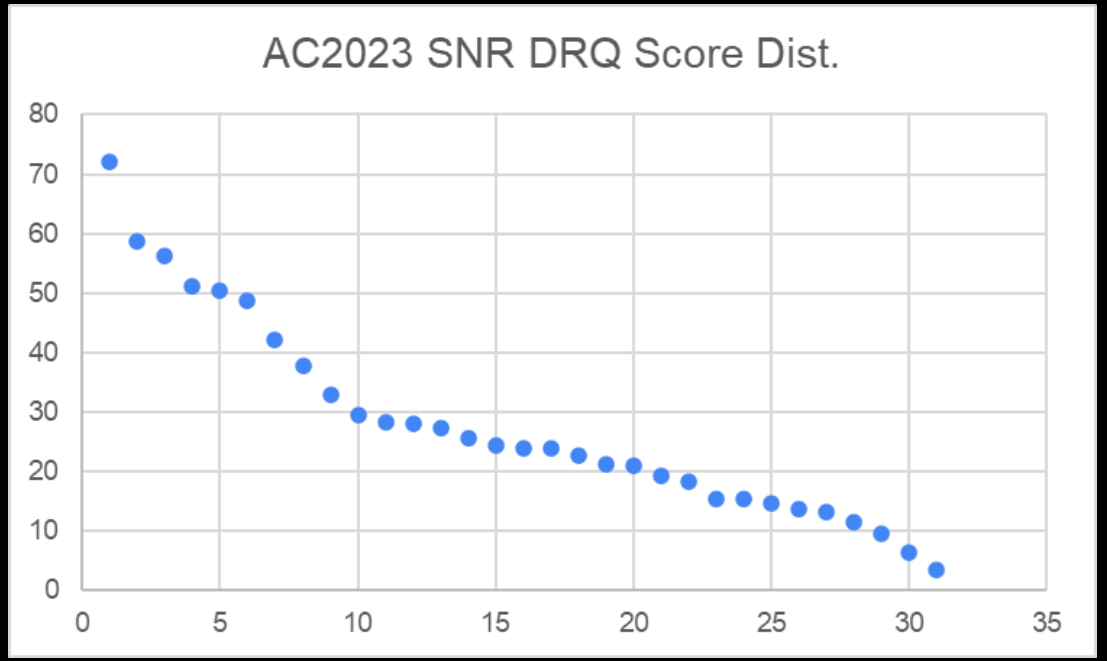
Statistics

Raw Scores

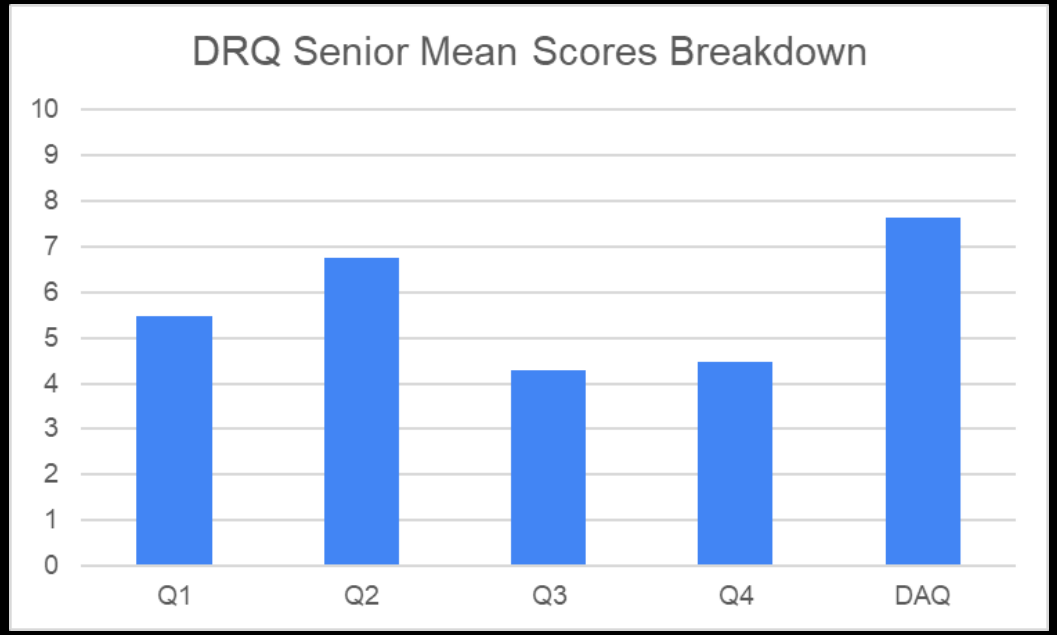
Mean: 28

Median: 24

HI: 72



Score Breakdown



Q1

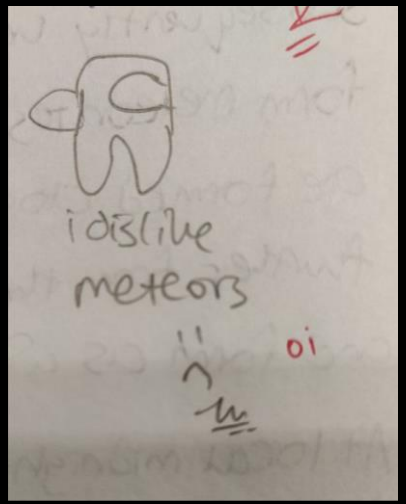
Wishing Upon a Star

Kaiwen

Summary

- Expectation: Friendly conceptual stargazing + solar system question to ease people in.
    - Fun fact: this question was originally meant for the juniors

- Reality:



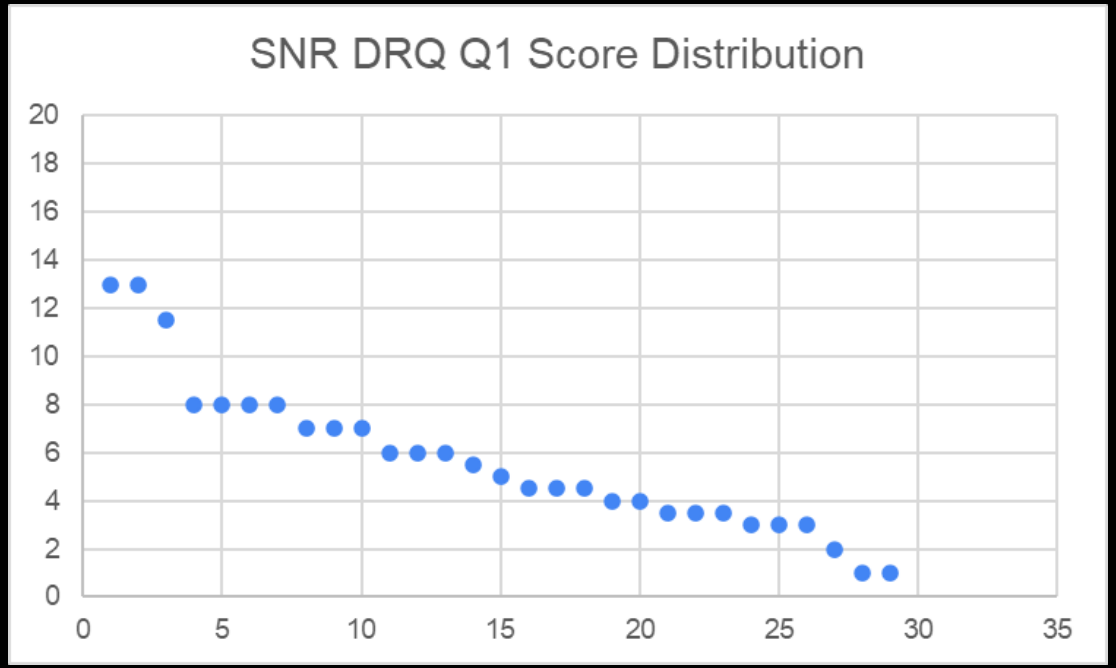
Statistics

Removing NIL Attempts

Mean: 5.3

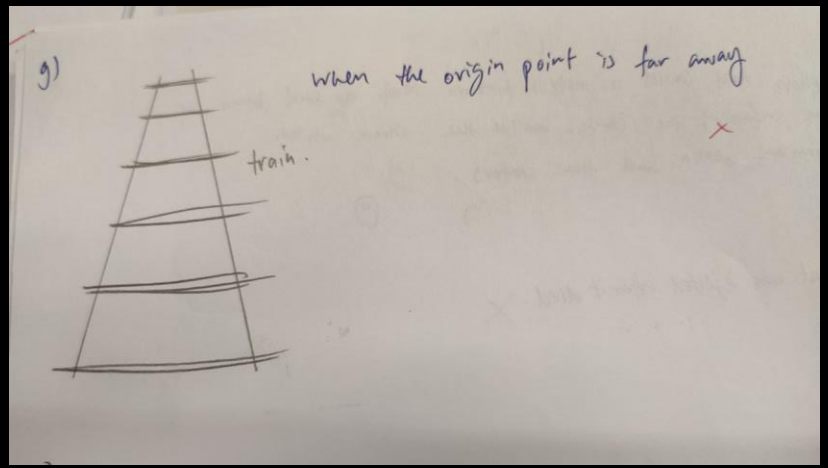
Median: 4.5

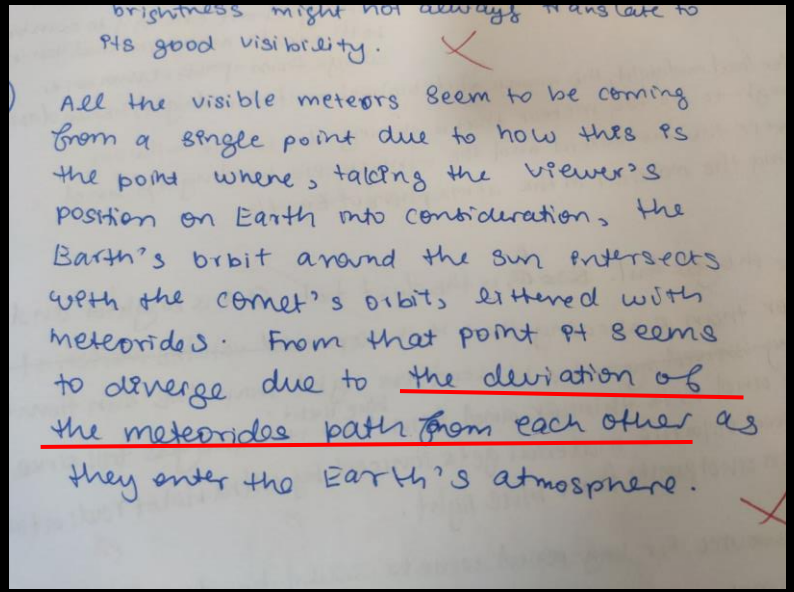
Hi: 13



(g) **Why do meteor showers originate from a radiant point? (Hint: Think about train tracks)** [2]

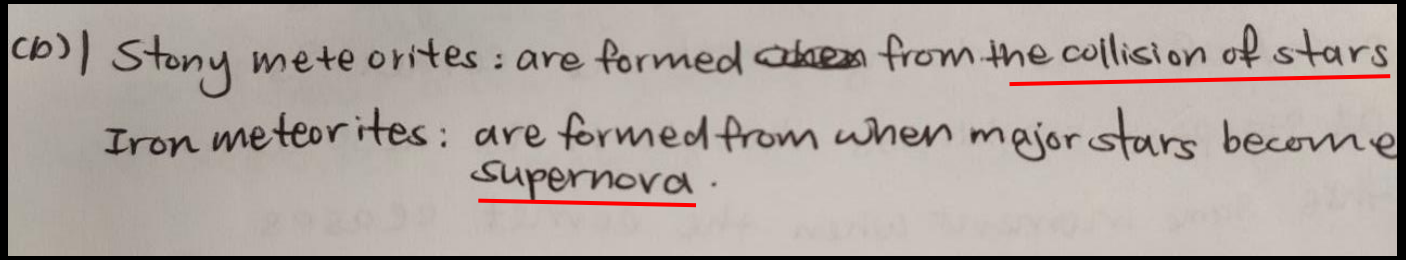
- Expectation: surely people understand how train tracks work?





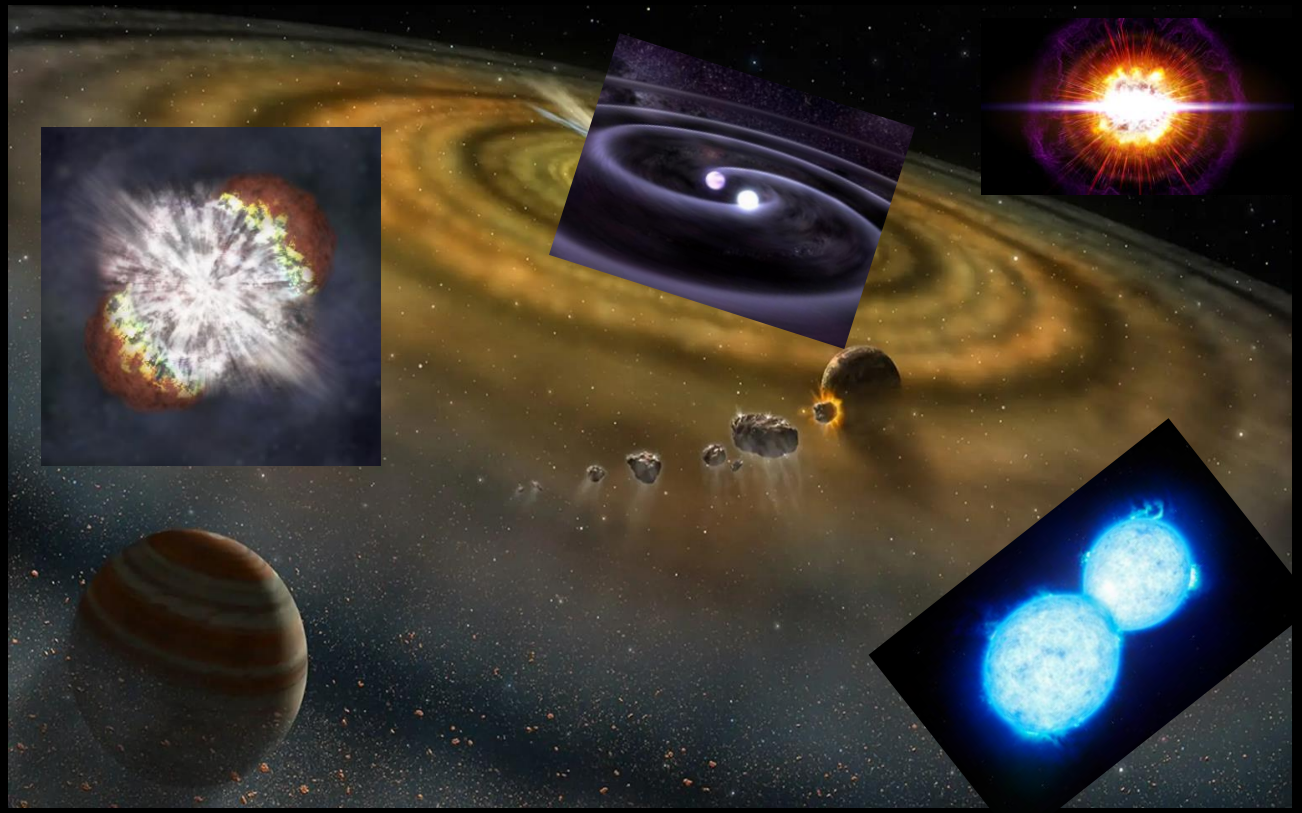
(b) Most meteorites are believed to originate from the early solar system. Given their origins, explain how the three types of meteorites might be formed during the early solar system.

- Expectation: surely people know the history of the solar system?


(b) Stony meteorites: are formed ~~where~~ from the collision of stars

Iron meteorites: are formed from when major stars become supernova.

The early solar system must be a hectic place…



When you give up - 2nd season 1st cour

j) Every 33 years, Saitama sensei travels to the Leonids and causes a supernova at one of the comets, releasing a galaxy-level explosion, causing a spike in ZHR. X

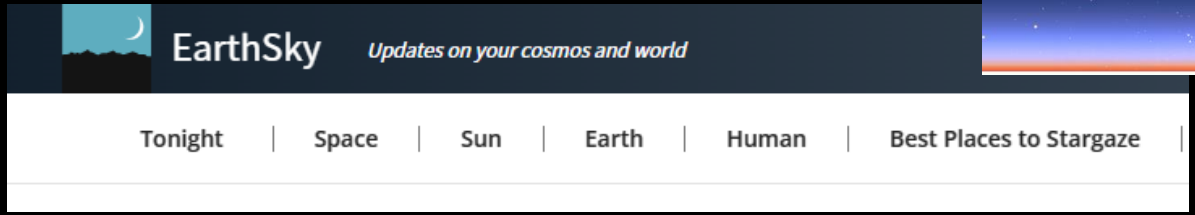
When you give up - 2nd season 2nd cour

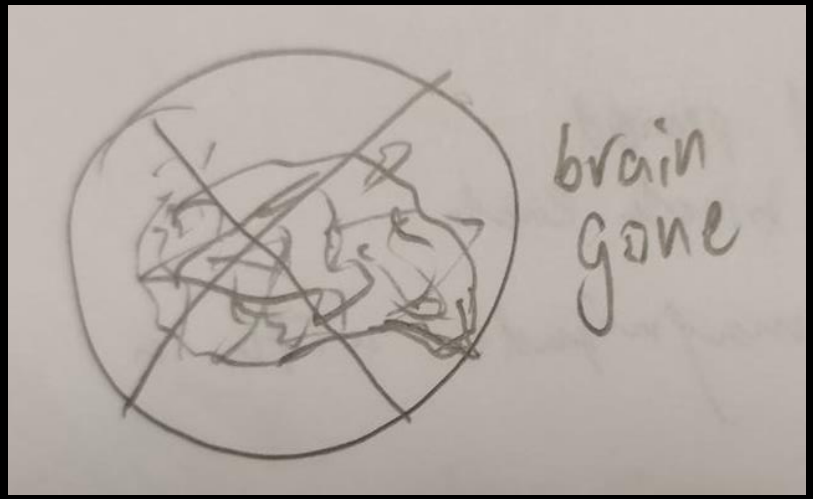
0.0

Given that every 33 years, the universe momentarily stops, this results in a momentary surge in acceleration of these Leonids in ZHR, hence they will be concentrated and therefore a large spike, thus a meteor storm. ✗

Remedy

- Read popular astronomy/stargazing articles!





Q2

Twinkle Twinkle Little Star in the Great Nebula

Jerry

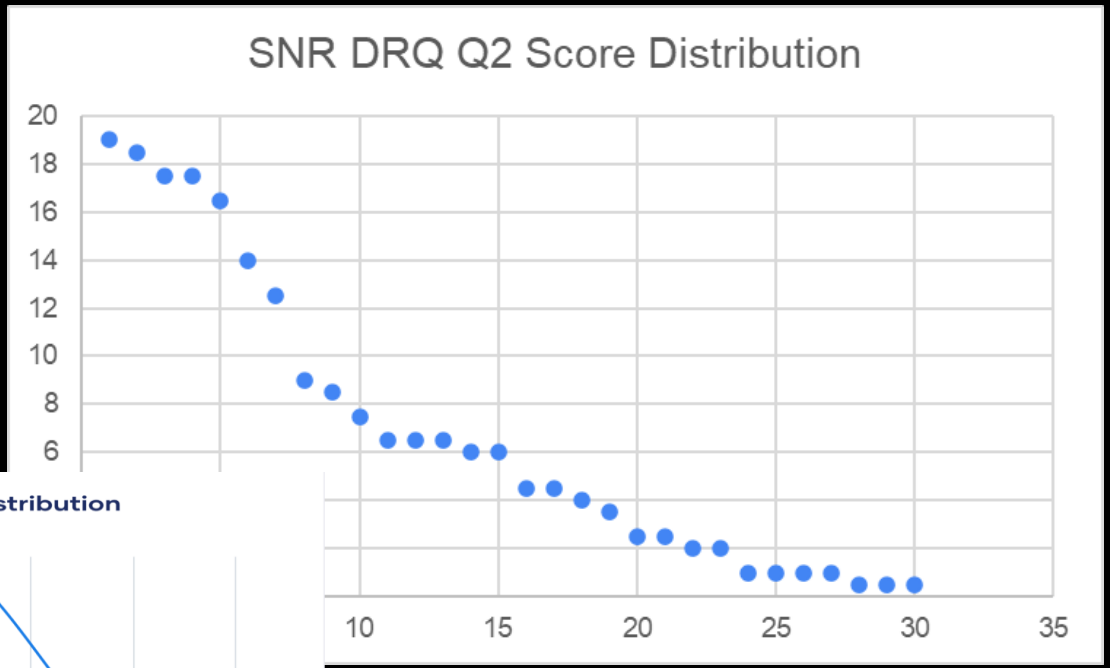
Statistics

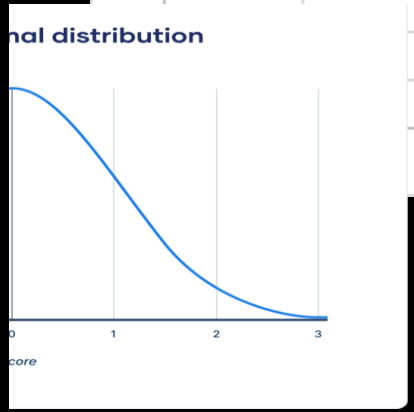
Removing NIL Attempts

Mean: 6.5

Median: 4.5

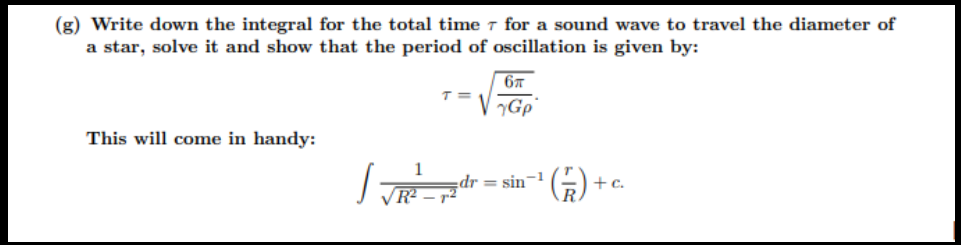
Hi: 19





Summary

- (Surprisingly) Most well-done question
- Many saw through the first integral as a bluff (it's just the Stefan-Boltzmann Law!)
  - The second integral was not a bluff though, so most people died



(g) **Write down the integral for the total time τ for a sound wave to travel the diameter of a star, solve it and show that the period of oscillation is given by:**

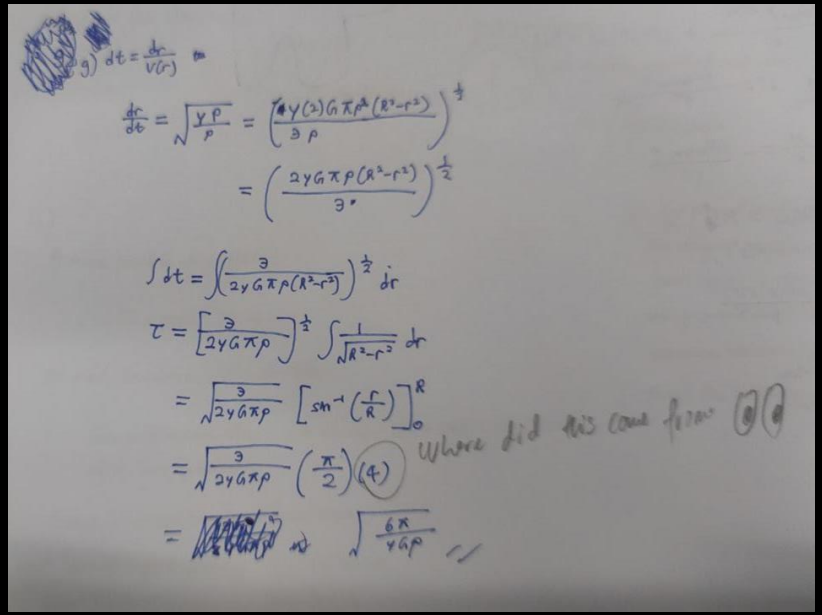
$$\tau = \sqrt{\frac{6\pi}{\gamma G \rho}}.$$

This will come in handy:

$$\int \frac{1}{\sqrt{R^2 - r^2}} dr = \sin^{-1}\left(\frac{r}{R}\right) + c.$$

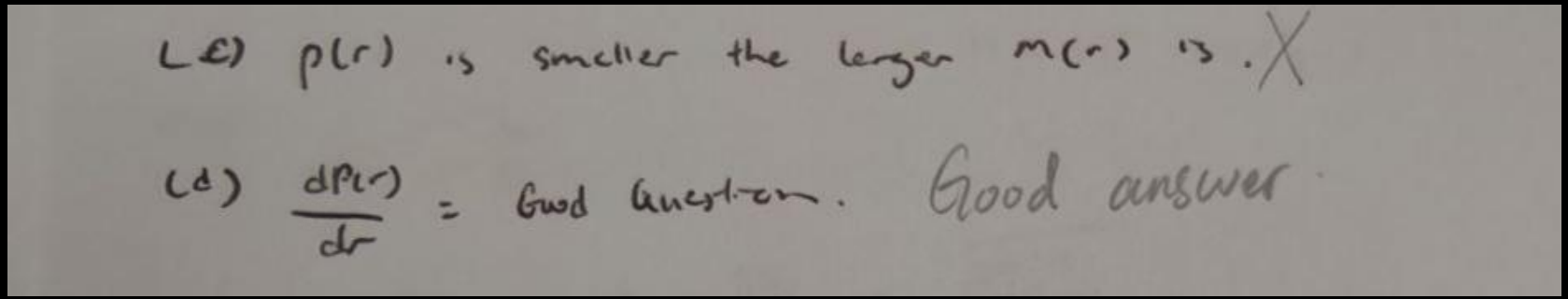
- Takeaway(?): Most SNR participants are still more comfortable with math than astronomy :(

Quick Note: Don’t underestimate your marker



- One team tried to sneak in a random factor of 4 so that their final derivation matches the answer.

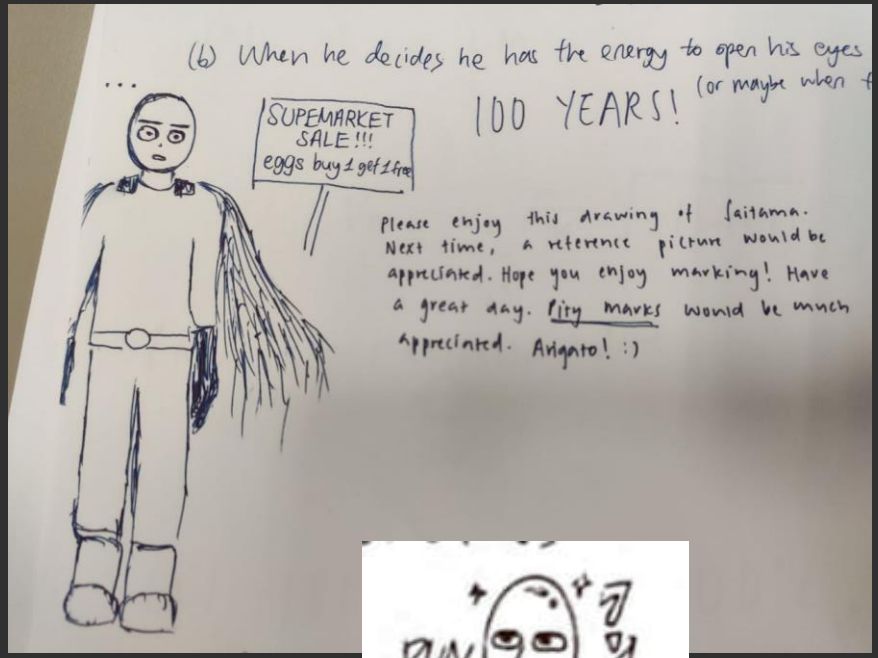
When you give up - OVA



Q3

Escape from the Solar System

Golf



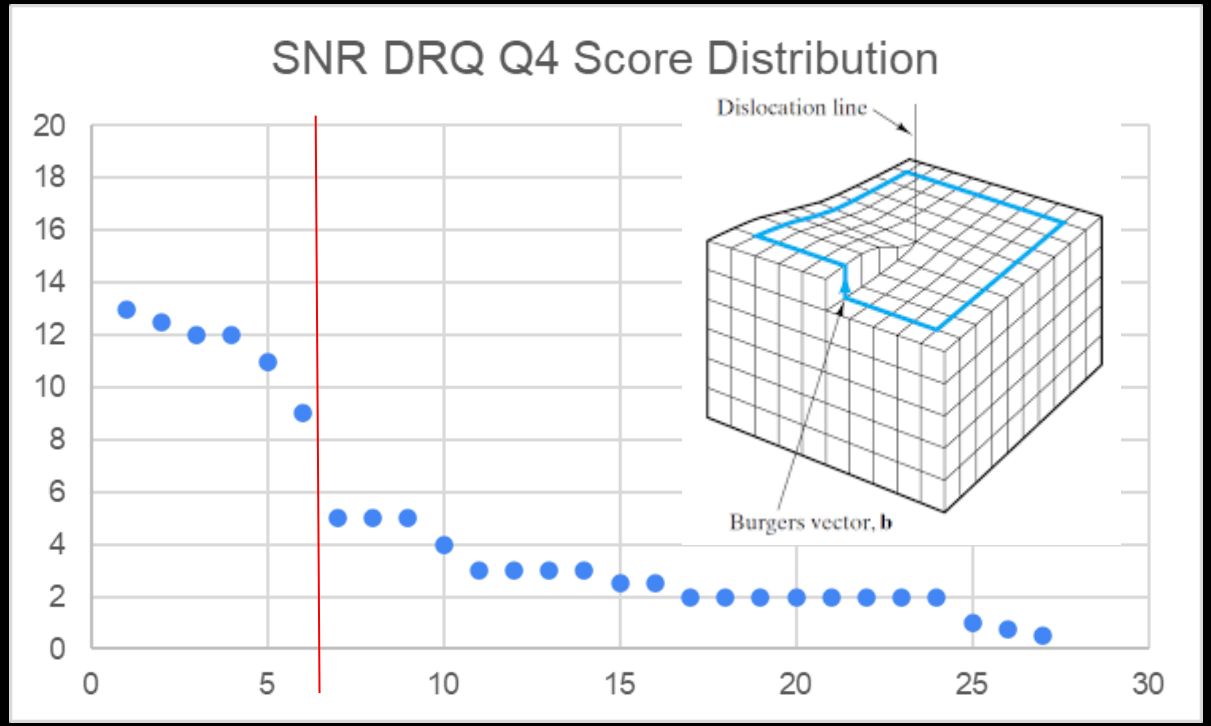
Statistics

Removing NIL Attempts

Mean: 4.1

Median: 2.5

Hi: 13



Live replay of AC senior participants reactions

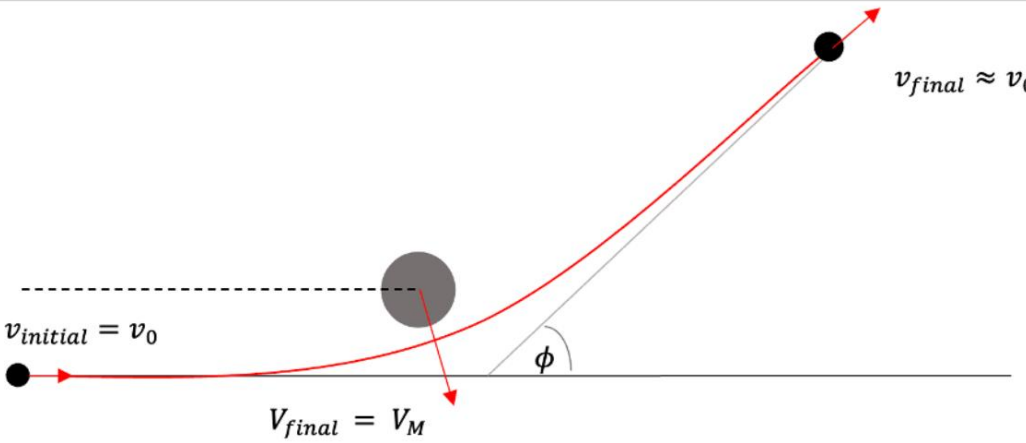
(a) Given the above simplifying assumptions, calculate the orbital velocities of both Jupiter and Earth. Express your answers in km s^{-1}. [1]

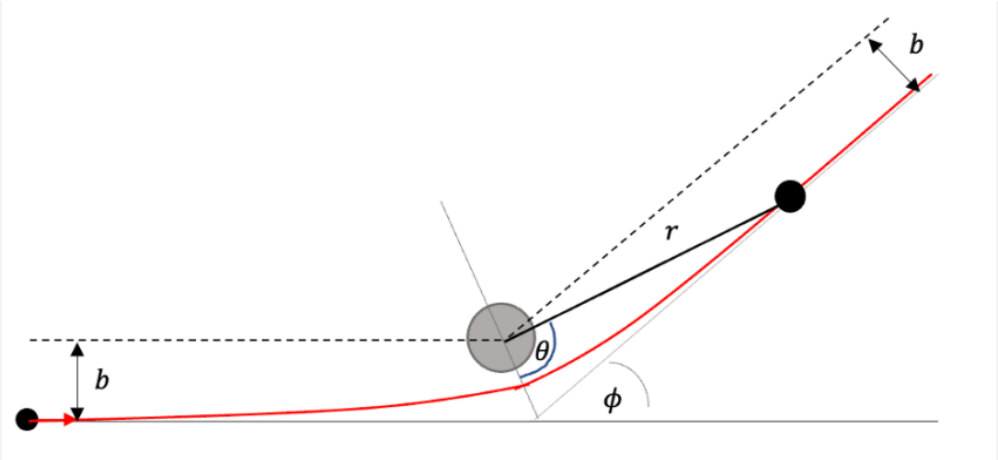
(b) How long will it take before Saitama is able to see Jupiter at opposition again? [2]

(c) **By considering energy and momentum conservation, show that $V_{E_f} \approx 2V_J + V_E$.**

(d) **Given that $V_{E_f} \approx 2V_J + V_E$ in the one-dimensional case, derive the expression for V_{E_f} for the two-dimensional case in terms of θ, M_J and M_E.** **[3]**

This relatively simple derivation should gives us some intuition
boost from slingshotting around Jupiter. However, notice that
specified angle at which the earth approaches Jupiter, θ, this do
the earth (imagine displacing the earth while leaving its velocity
result in a different trajectory, but our derivations do not take t
the symmetry requirement, we have already made a particular i
describe the trajectory of Earth, we need a few more ingredients


$v_{final} \approx v_0$
$v_{initial} = v_0$
ϕ
$V_{final} = V_M$


b
r
θ
b
ϕ

(e) **Express the angular momentum L and total energy E of the small mass m in terms of the initial speed of the small body v_0 and the impact parameter b.** [2]

(f) **Thus, express the constant C and eccentricity e as given by (6) in terms of the mass of the large body M, v_0 and b.** [1]

(g) **From equations (5) and (6), derive the expression for r_m, the closest distanc mass m and mass M as mass m moves along its trajectory, in terms of M, v_0**

$$\phi = 2\theta_{max} - \pi$$

(h) **Thus, derive the expression for the deflection angle ϕ in terms of v_0, b, and M.**

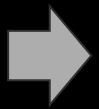
Important PSA

- This is frankly a very difficult question
  - Don’t be disheartened if you couldn’t do it…it is not really an astronomy question either

Lvl 1: Plug in formulae and press calculator

Lvl 2: COM/COE

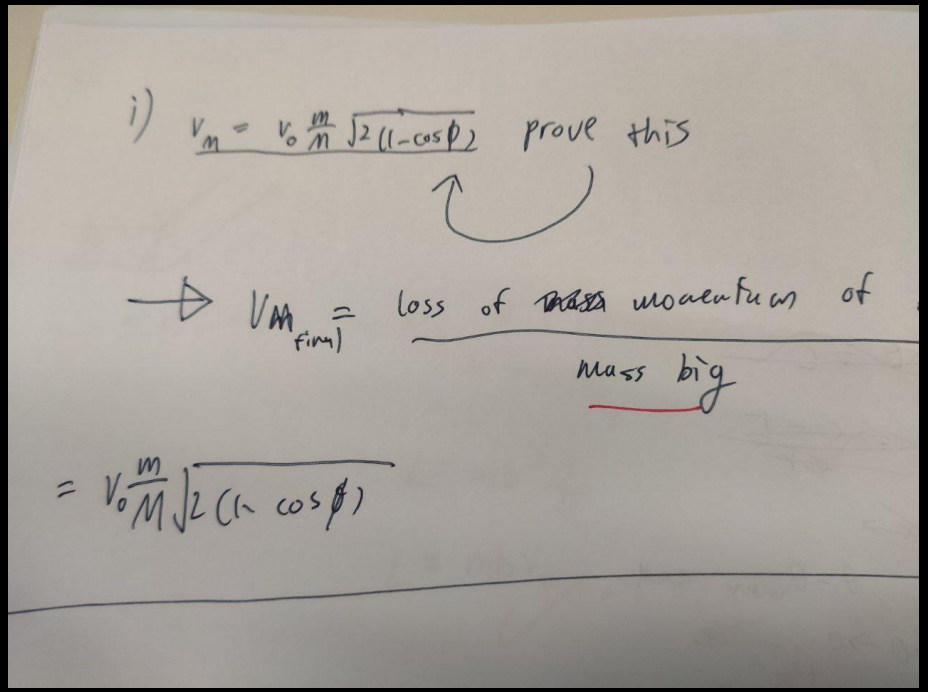
(A lvl Physics)



Lvl 3: Parametrizing the trajectory of an object

(Uni Phys/Eng)

Derivations can be challenging



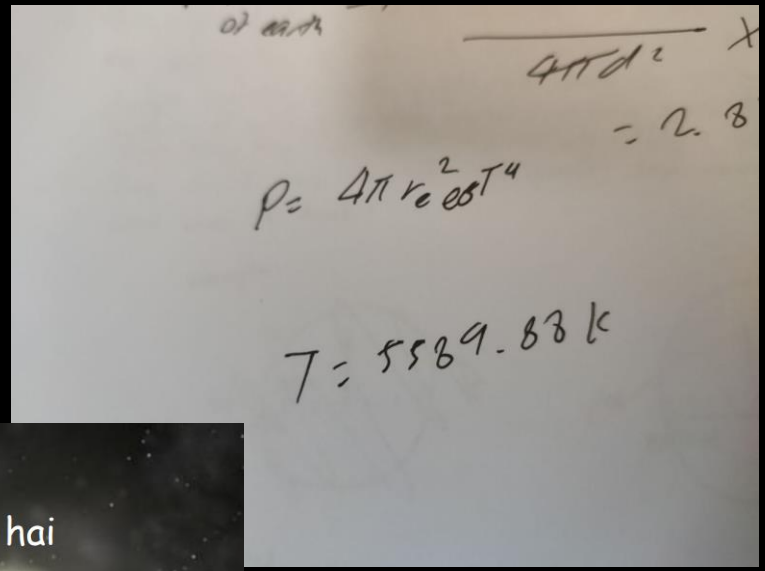
Most rigorous physics derivation

How to spot calculation mistakes

- Develop physical intuition (takes time)
- Check order of magnitudes
  - (there is an estimation round in finals for a reason!)

How hot can a planet be?

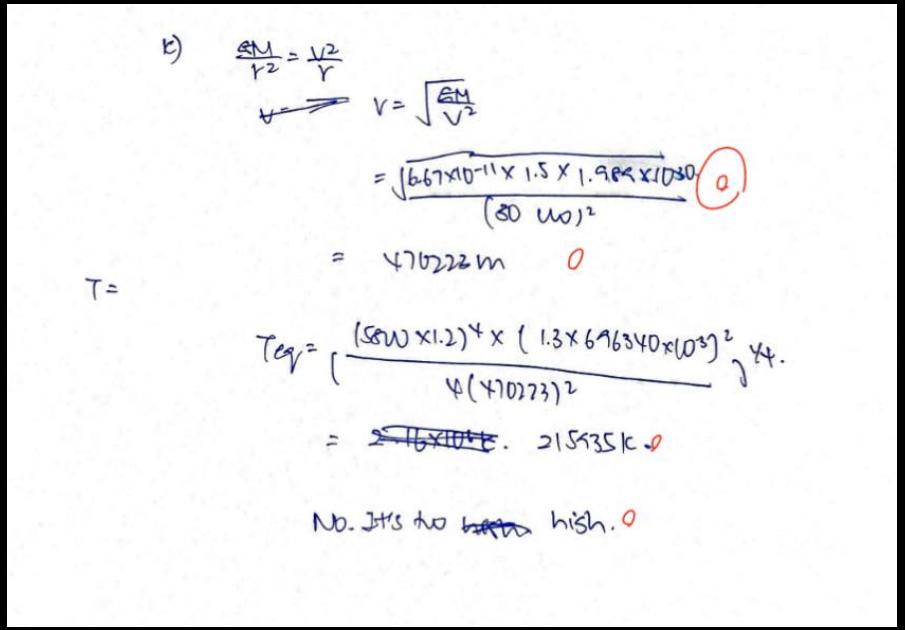
- T = 5389.83 K (too many s.f.!)
- Surface of the Sun: 5772 K

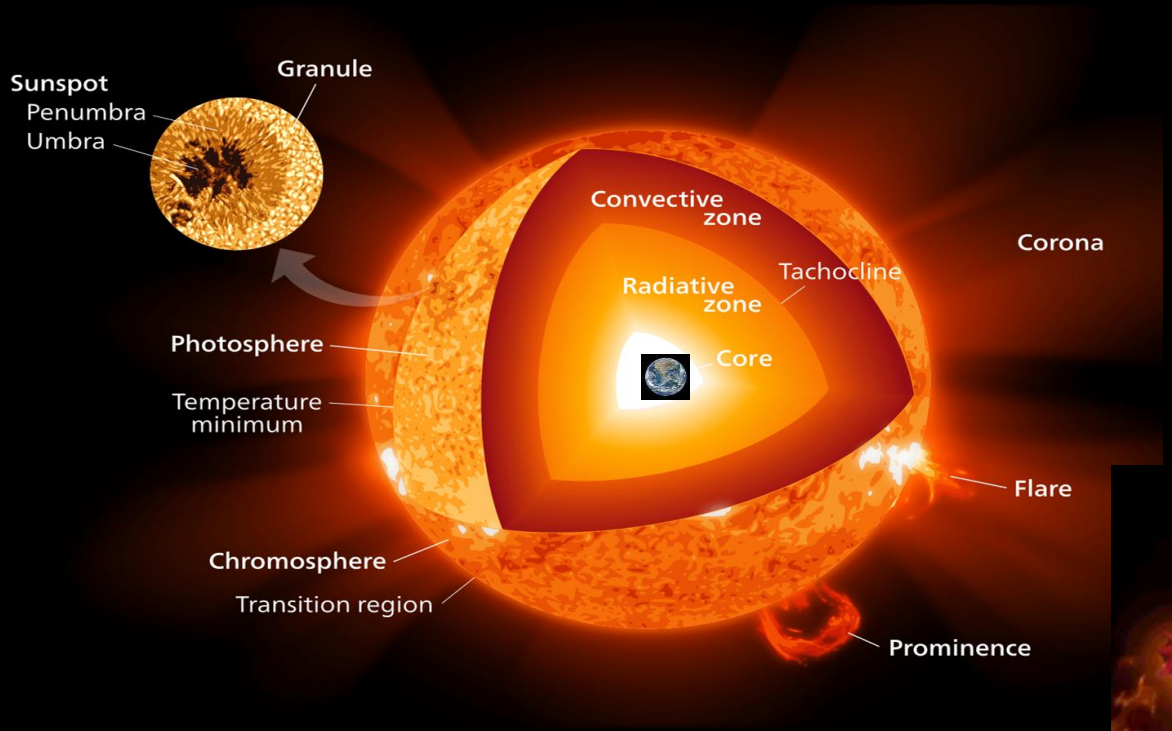


How hot can a planet be? #2

- T = 215935 K (40 times hotter than the surface of the sun!)

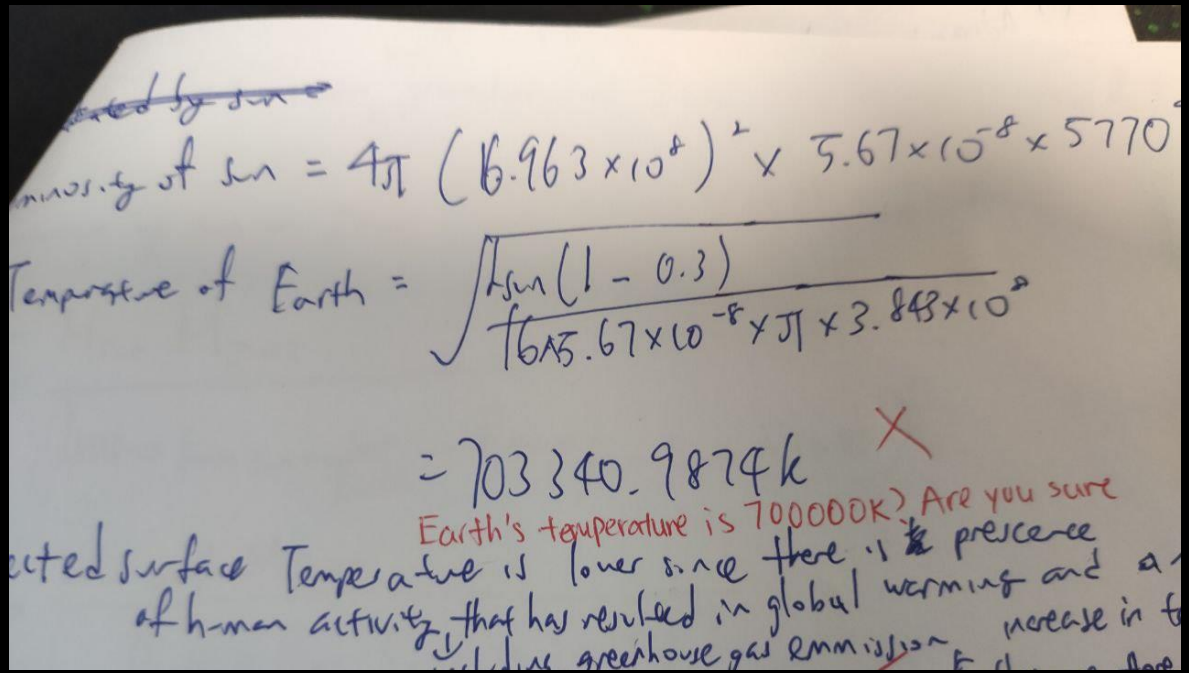
- The culprit: Orbital radius calculated to be 4x10^5 <u>metres</u>
- Radius of the Sun: 7 x 10^5 <u>kilometres</u>





Turns out the estimate of 215935K is a tad low…

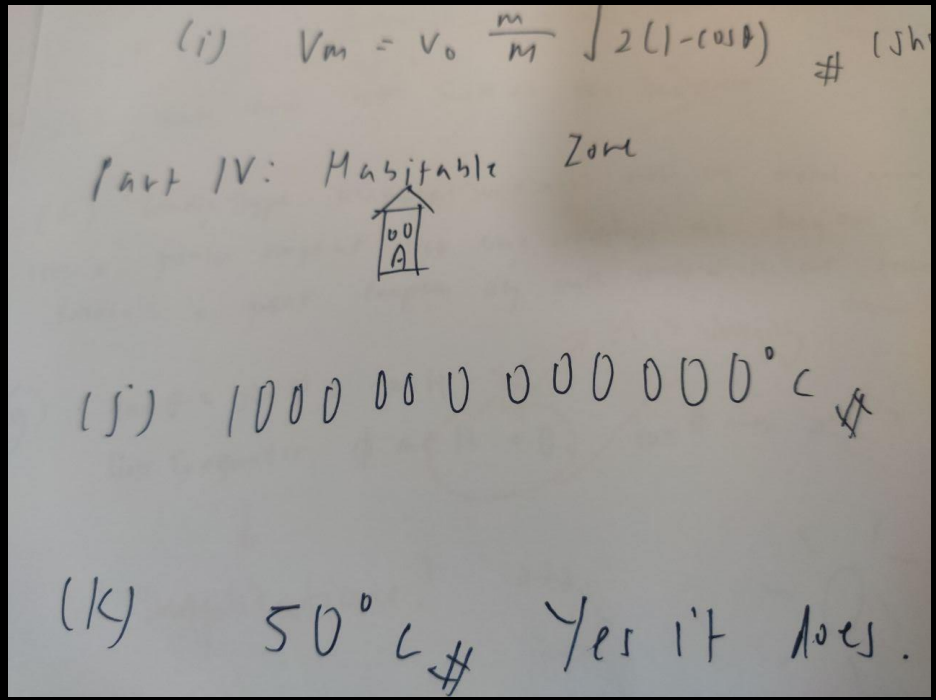
Contestants from the Junior DRQ



Is this our highest bidder?

- 1x10^12 Kelvins

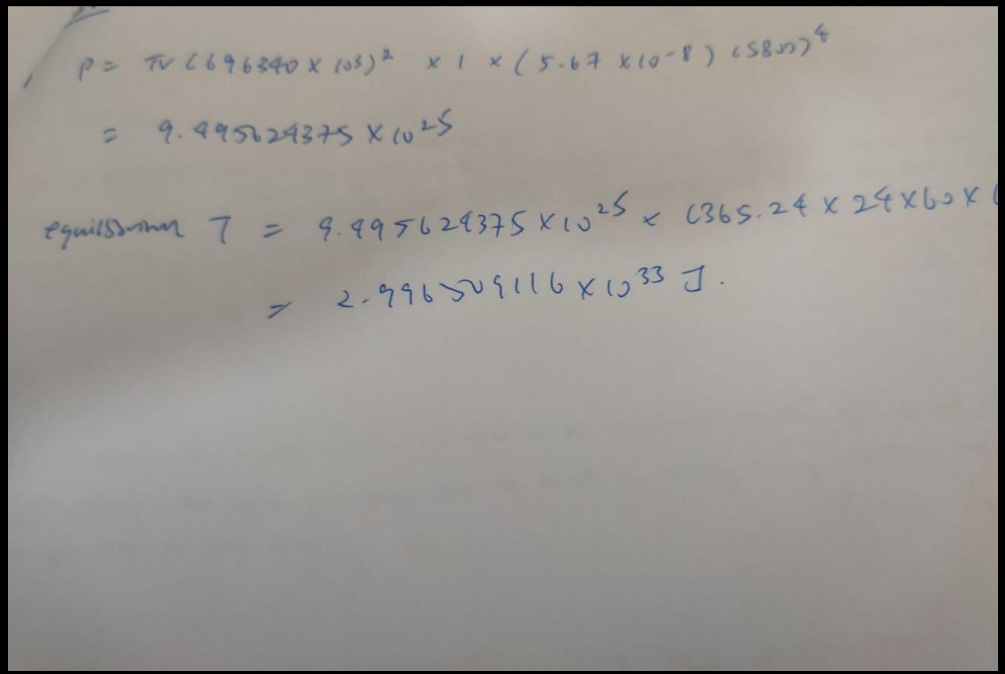
= 1 million X



Throwback Time! (see AC2016 PM)


A new foe has appeared!
CHALLENGER APPROACHING

Our grand winning bid:



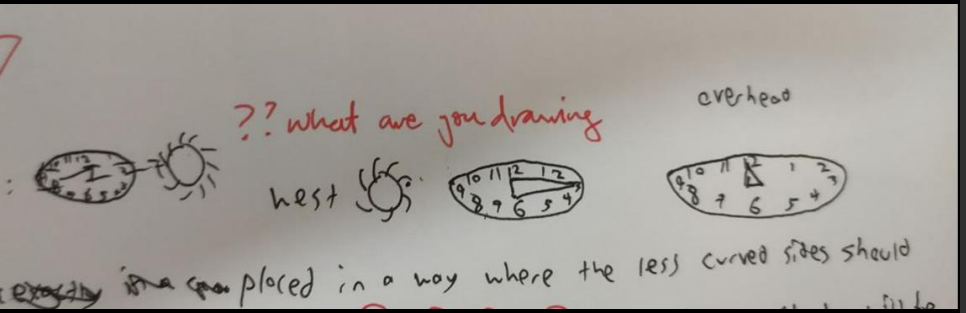
- Temperature is 10^33 Joules?
  - This actually makes sense in plasma physics for electron temperature!

- Let’s do a conversion:
- 1 eV = 11605 Kelvin
- 1 J = 6.2 x 10^18 eV
- 10^33 J = 1.1 x 10^55 Kelvin

How hot is 10^55 Kelvin?

- Temperature at the start of the big bang: 10^10 Kelvin
- = 10^45 big bangs

- Lesson: Units matter! (a lot)



Q4

An Afternoon at the Sundial Garden

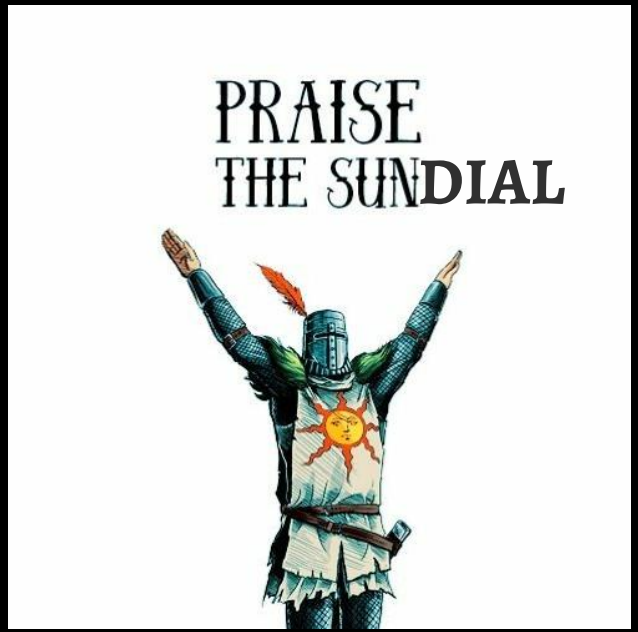
Ken Rui

Rationale

- Historical role of astronomy in timekeeping
- Focus on concepts rather than math
- Filter those who can do physics but not astronomy

Reality:

- Everyone got filtered



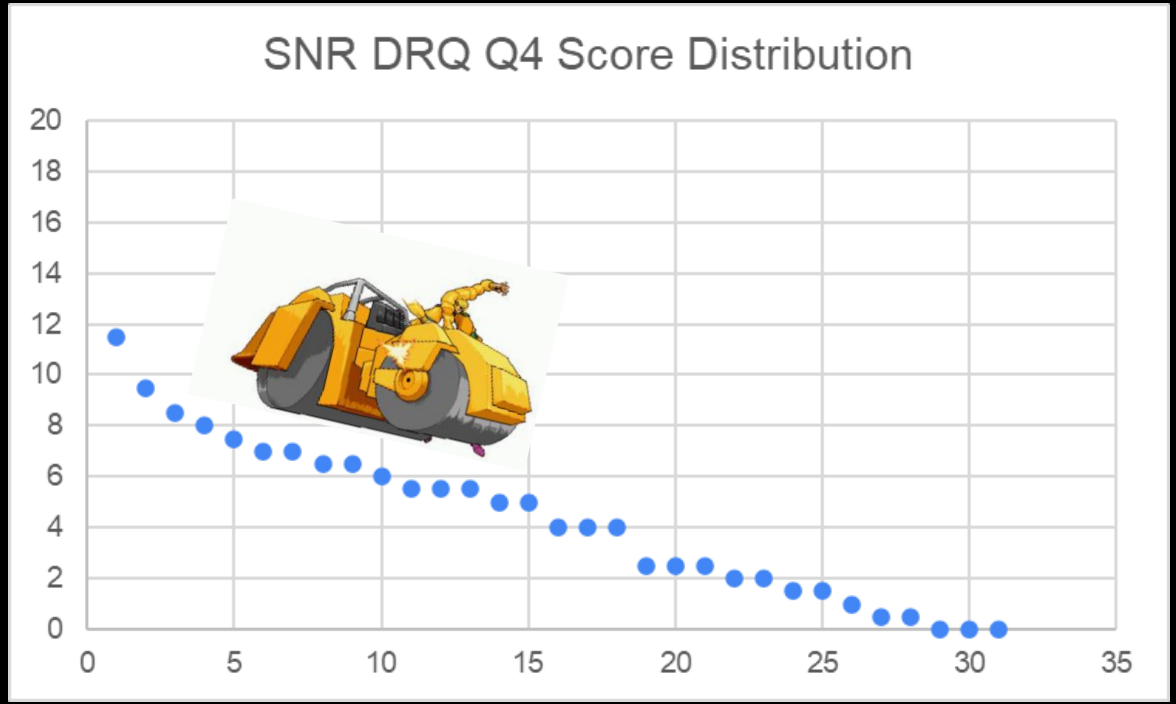
Statistics

Removing NIL Attempts

Mean: 4.32

Median: 4

Hi: 11.5



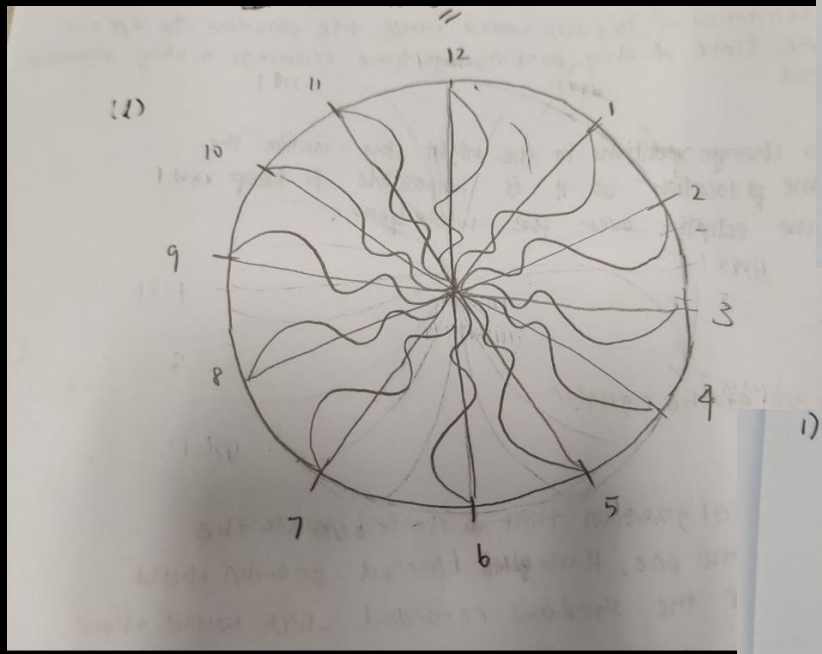
Killer Question (most zeros)

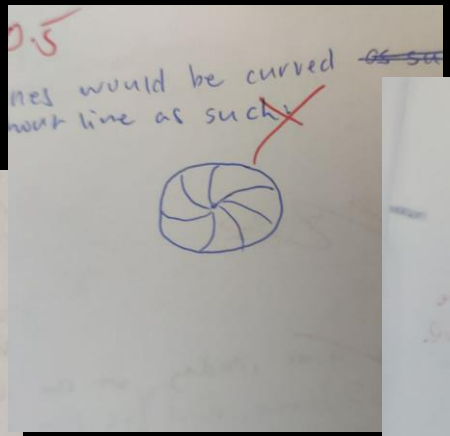
It should be possible to construct the hour lines on a nodus-based sundial such that it automatically compensates for the equation of time. This is done with a curved hour line that is ahead or behind the original straight hour line at points corresponding to different solar declinations, with the time difference given by the equation of time.

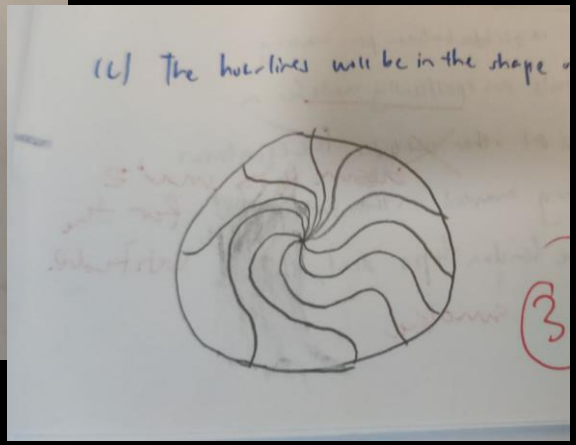
(l) **Describe the shape of the hour lines if such a correction was to be applied. You may supplement your description with a sketch if needed.** **[2]**

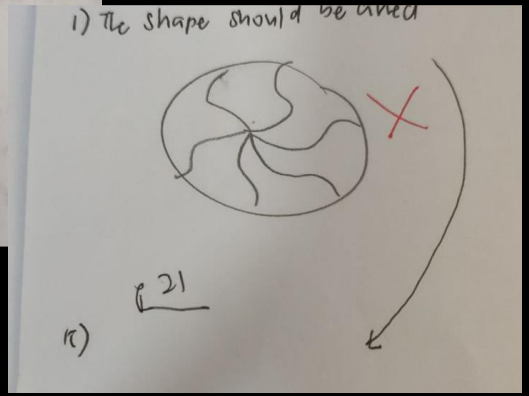
*Don’t worry, this was meant to be difficult

Tasty Dumplings







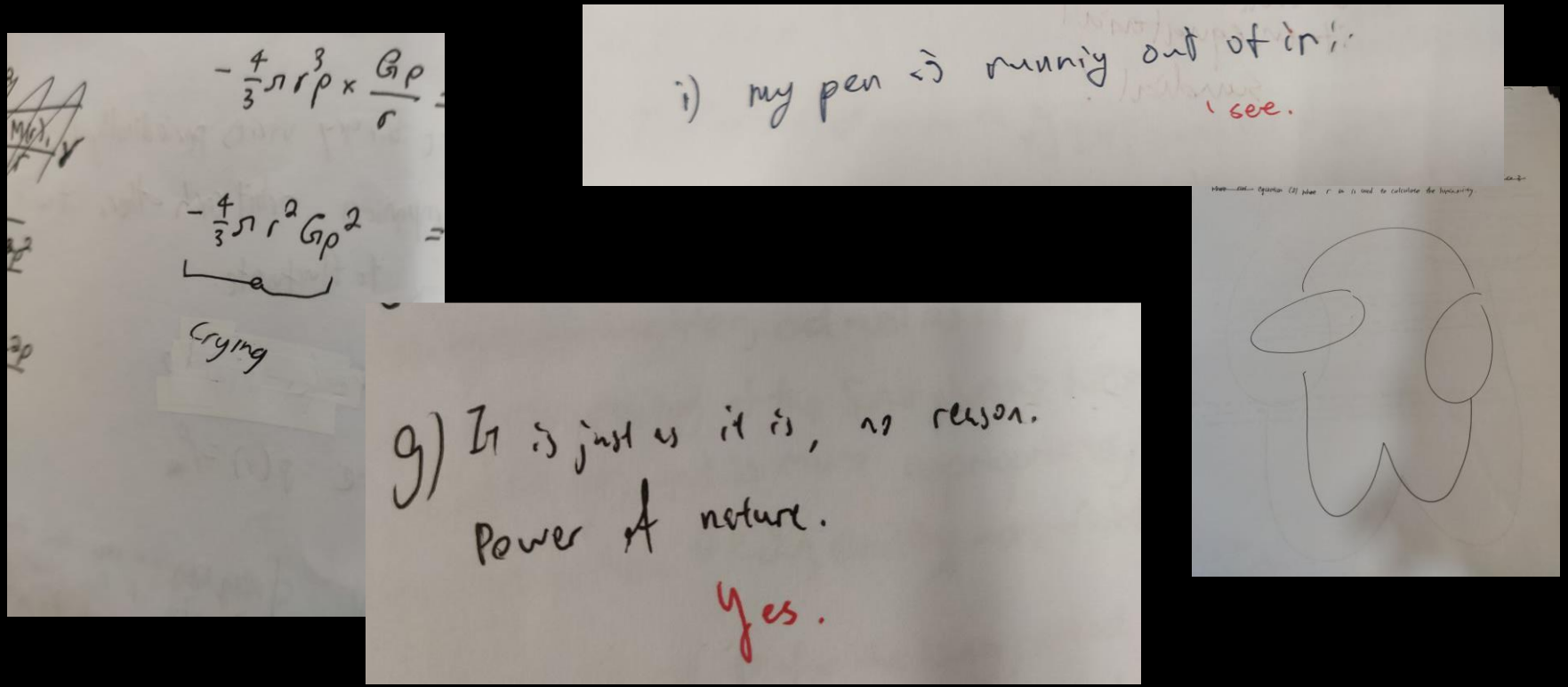


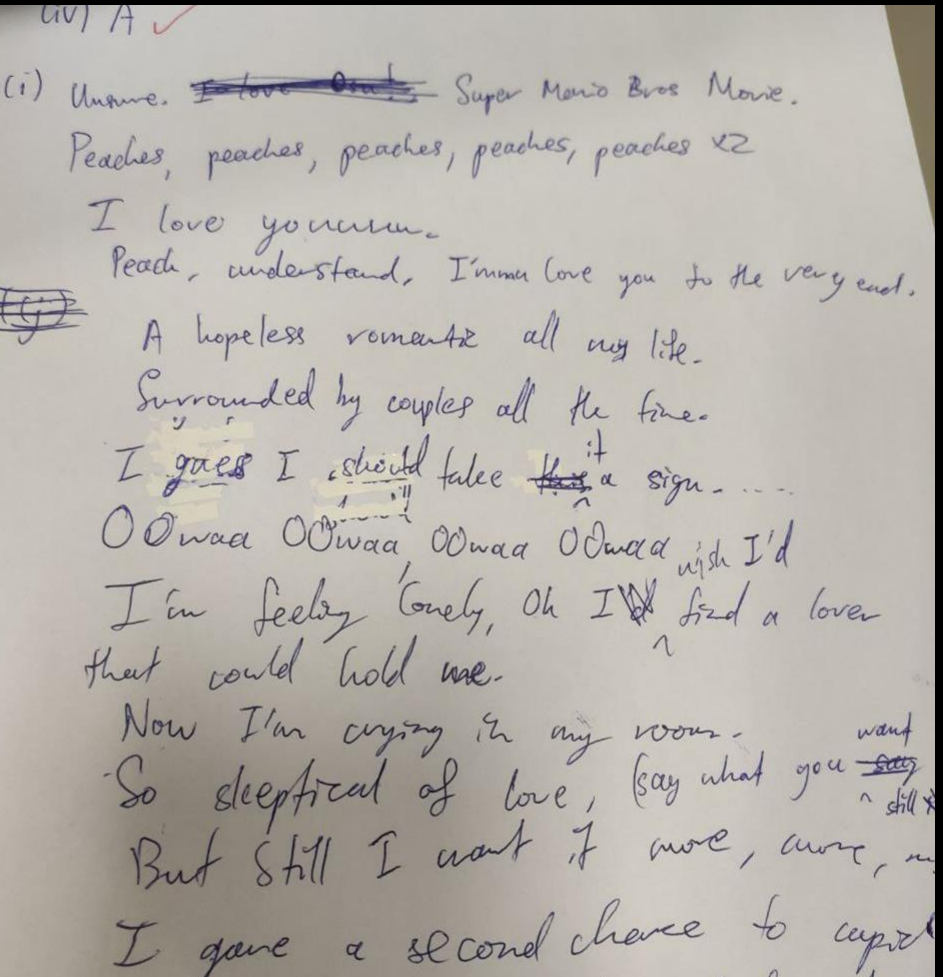
Your logic:

1. Sundial hour lines are like clock faces
2. Equation of time is curvy
3. Make hour lines curvy

You’re on the right track, but the whole point of the question is to debunk premise 1!

When you give up - Final Season




(ii) A

(i) Unsure. ~~I love Ost~~ Super Mario Bros Movie.

Peaches, peaches, peaches, peaches, peaches x2

I love yoooou.

Peach, understand, I'mma love you to the very end.

~~F(y)~~

A hopeless romantic all my life.

Surrounded by couples all the time.

I guess I should take it ~~this~~ a sign....

OOwaa OOwaa OOwaa OOwaa wish I'd

I'm feeling lonely, Oh I ~~wish~~ find a lover

that could hold me.

Now I'm crying in my room. want

So skeptical of love, (say what you ~~say~~ still

But still I want it more, more, m

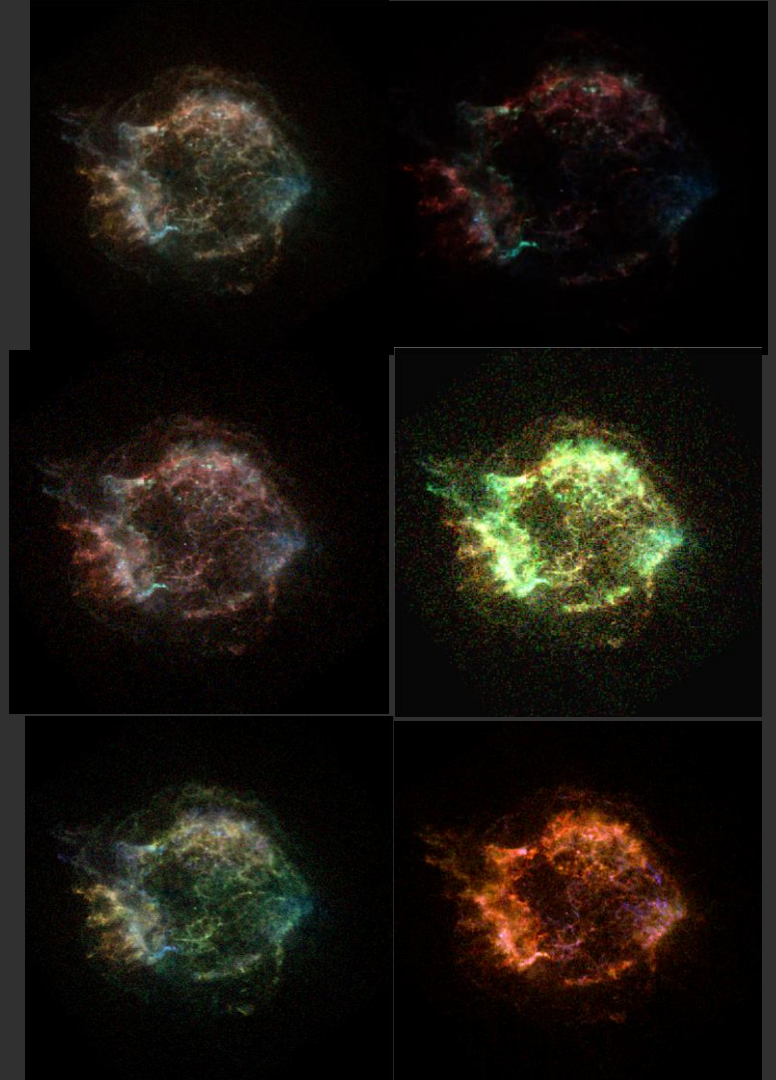
I gave a second chance to cupi

Least insane Princess Peach simp

DAQ (Senior)

Data Analysis Question

Benjamin



Rationale

- Introduction to a few tools and the data analysis process of Astrophysics-related research.

    - Observation → Data Collection and Processing → Data Analysis → Data Visualization → Inference Making

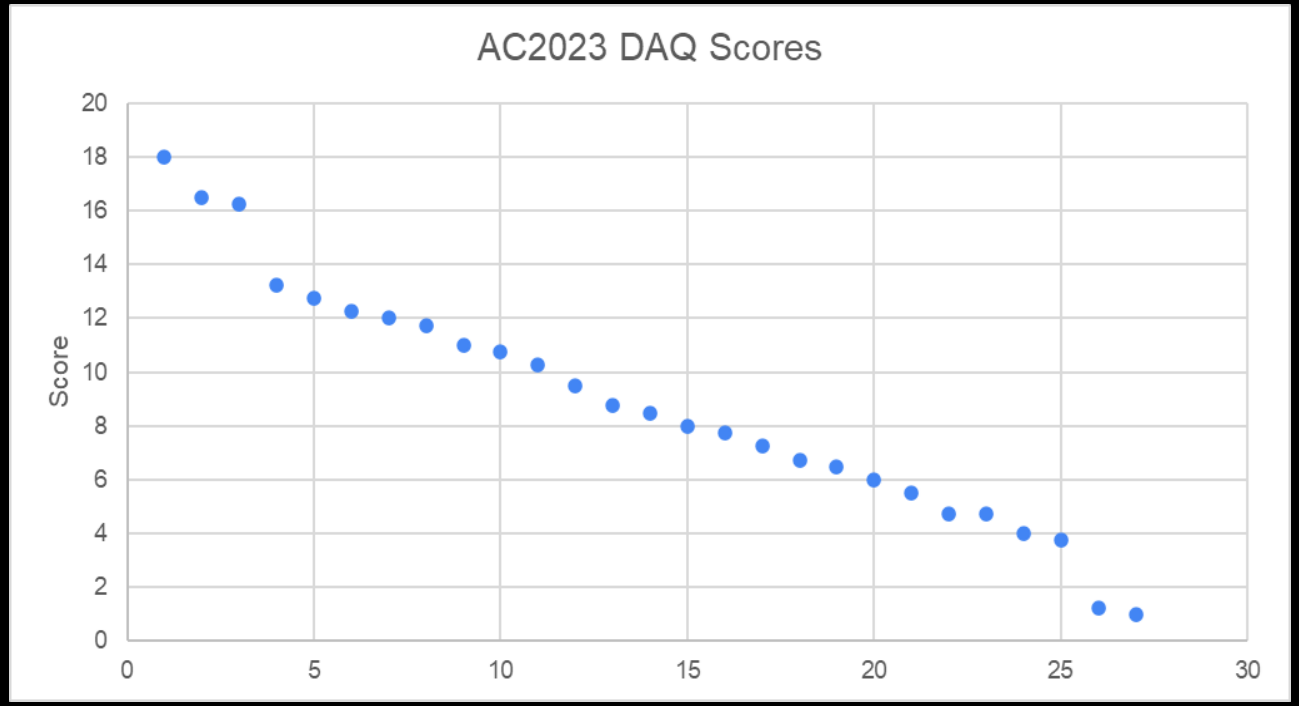
Statistics

Removing NIL Attempts

Mean: 8.84

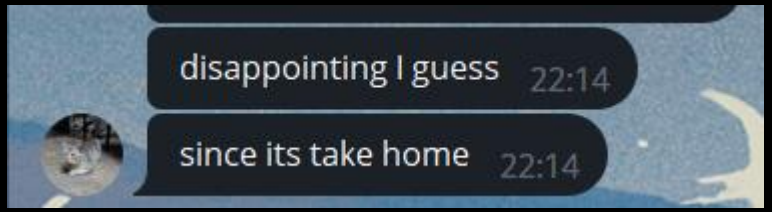
Median: 8.5

Hi: 18



Killer Questions were 1a and 2e

A word from your marker when we asked him how were the submissions…



Teams that spent time and put in effort did significantly better!

General Complaints

- Some did not follow instructions clearly…
  - Did not save .fits file as rgb image
- Shallow research done. Evident in responses
  - Referencing with no evidence provided is not substantial.
  - Those that did research performed vastly better overall.
- Answers were long-winded and missed the mark
- Random math taking place due to panic.
  - There’s no time limit!

Exemplary Case

- Excellent Research showcase

slots for the lower image values than the higher image values. (C. Patterson, 2011) This highlights low luminosity features in the image that may not be noticeable with a linear scale. It helps to accentuate faint maxima, where there is a bright source in the field. (SAO, n.d.)

1.5

good

1. "Explore LAT Data"- SLAC Stanford University (Published by Chuck Patterson-03/02/2011)[link]http://vizier.u-strasbg.fr/doc/man/saoimage.scale.htx
2. "Scaling from image pixel value to displayed colours in SAOimage"- Smithsonian Astrophysical Observatory (SAO) [link] http://tdc-www.harvard.edu/software/saoimage/saoimage.scale.html

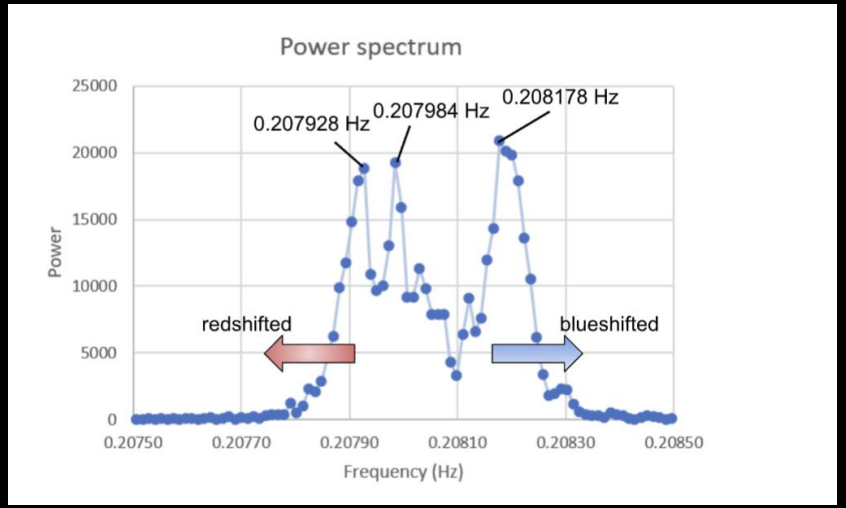
- Good citations but wrong use case

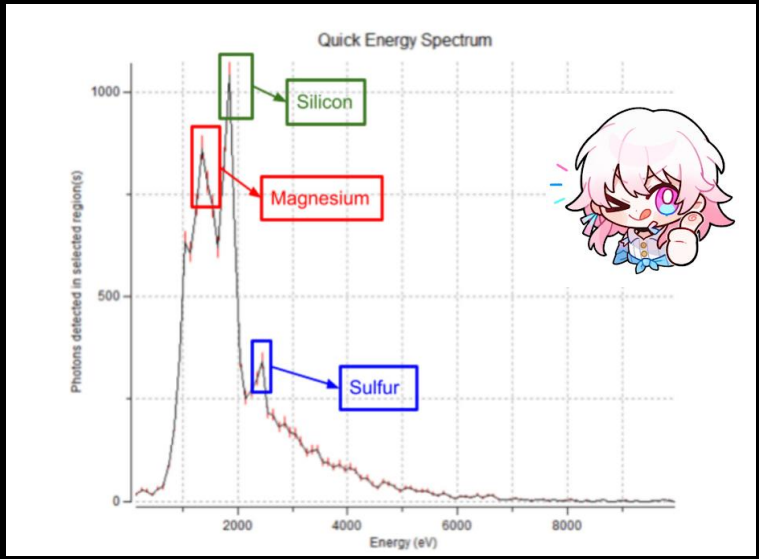
Cen-X3 mass = 1.21 Solar Masses
Companion star mass = 20.5 Solar Masses
(Ref. Naik, Sachindra; Paul, Biswajit; Ali, Zulfikar (August 2011))
(Sorry, we could not figure the last 3 out despite our best efforts 😢)

its ok

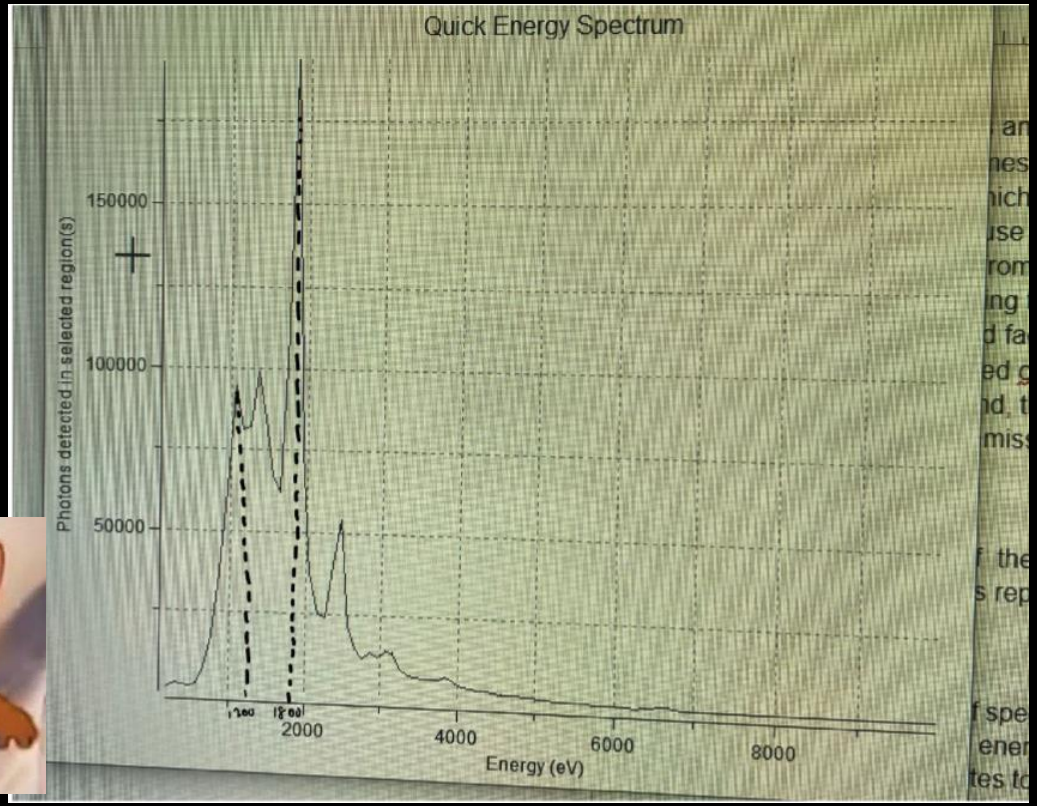
Exemplary Case

- Well-labeled Diagrams





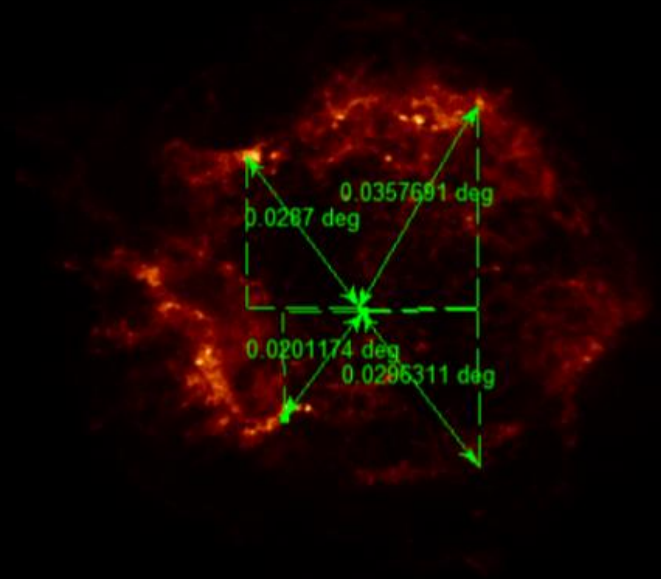
Negative Example…



Surely AC participants are young enough to know how to export image files??

Exemplary Case

- Using multiple points to improve accuracy (thinking like a scientist!)



Random fails

Random Calculations

$M1+M2=a^3/p^2$

Mass of binary system= $a^3+p^2=0.079277797^3+0.005561644^2=5.29190388 \times 10^{-4}$ AU

$MP^2 = a^3$

Mass= $a^3*p^{-2}=0.079277797^3 \times 0.005561644^{-2}=16.10824949$ AU [1] ???

where did you get this number?

$$365.25 \times 86400km = 631152000km$$

Not Calculating, just Googling

10 light years (Google gives the radius of Cassiopeia A to be 5 light years)

(h) What is the mass of the Cen-X3 and its companion star respectively?

(Wiktionary: https://academic.oup.com/mnras/article/307/2/357/1104307?login=false)
Mass of Cen-X3: 1.21±0.21 M.
Mass of companion star: 20.5±0.7 M.

lol

Forgetting Relativity

Thus, Maximum radial velocity of Cen-X3,

$$V_r = c \times \frac{\lambda_{max} - \lambda_{rest}}{\lambda_{rest}}, \text{ where } c \text{ is the speed of light and } \lambda = \frac{c}{f}$$

$$= 2.738209 \times 10^{12}\, ms^{-1} = 2.74 \times 10^{12}\, ms^{-1}\,(3s.f)$$

These are 9150c!

$$\text{Maximum radial velocity} = c \cdot \frac{\Delta\lambda}{\lambda_{rest}}$$

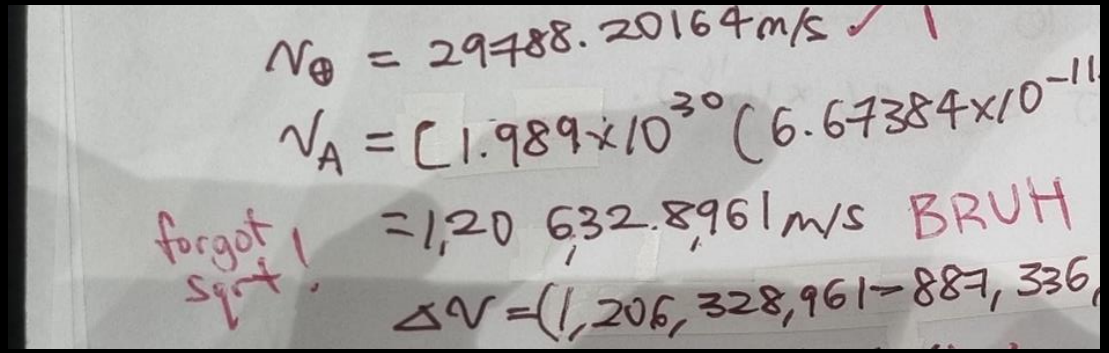
$$= c \cdot \frac{\lambda_{max} - \lambda_{rest}}{\lambda_{rest}}$$

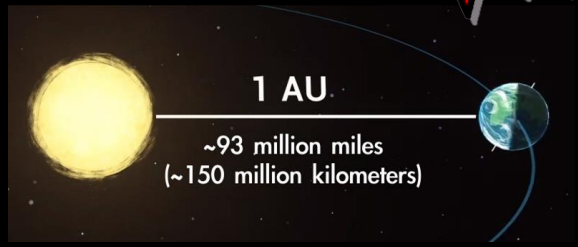
$$= c \cdot \frac{\left(\frac{c}{f_{min}}\right) - \left(\frac{c}{f_{rest}}\right)}{\left(\frac{c}{f_{rest}}\right)}$$

$$= 3.00(10^8)\left(\frac{\frac{3.00(10^8)}{2.276(10^{-5})} - \frac{3.00(10^8)}{0.20817784}}{\frac{3.00(10^8)}{0.20817784}}\right)$$

$$= 2.7437\,(10^{12})\, ms^{-1}$$

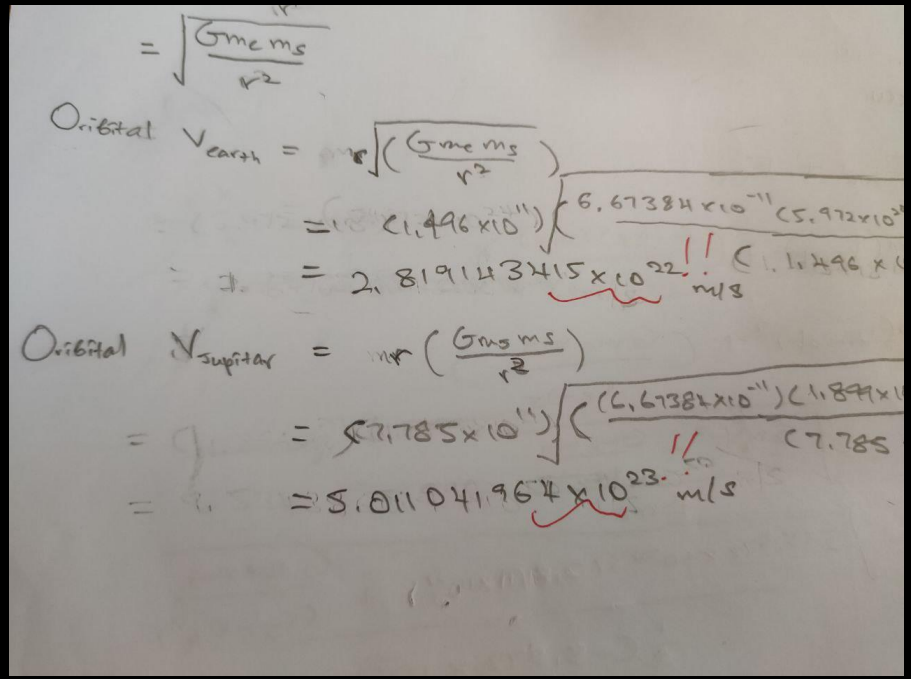
Juniors: Watch this

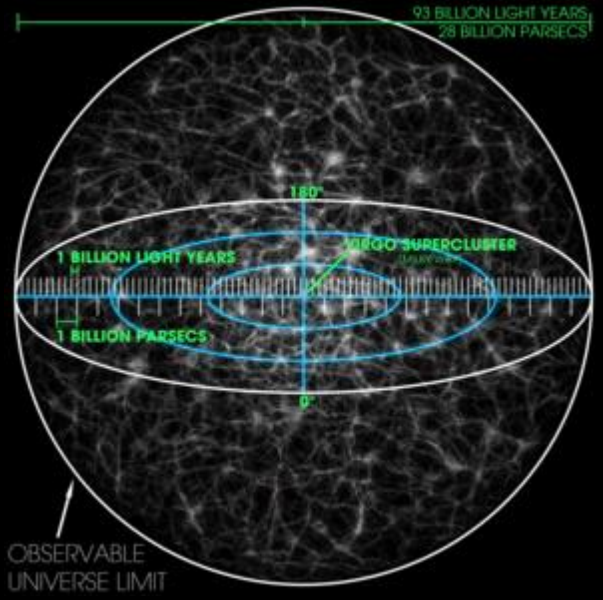




2 minutes
Up: 8 minutes

Seniors: ok but hold on





30 mins drive

To quote the 2017 postmortem…

If you get answers like this, the universe is screaming at you to check your work.

That’s all folks!

- AC2023 QMs