AC Post Mortem

Project Round Videos

Project Round Videos and then some…

- Do not use Powtoon anymore
- We generally prefer videos with subtitles
- Some schools showed very minimal effort, answered the question and ended, but it was fine…
- Some didn’t even used up to 2min
- Some had too many meme references, minimal relevant content
- Some were really very boring…

Day 1: MCQ & DRQ

MCQ

Troll Question of the Year

- Q2: One night at an unknown location, the Moon was observed to be rising over the horizon. An observer reads off her broken watch and found that the time on her watch right then was 22:50. The phase of the Moon is a…
- Local solar time is what matters!
- JNR (64% correct)
- SNR (60% correct)

MCQ (Easiest Question)

- JNR; Q23
  - What is the main reason why there are no planets located within the asteroid belt? (80% correct)

- SNR: Q14
  - Why don’t aeroplanes, which are also circling the Earth, experience zero-G? (91% correct)

MCQ (Least Correct)

- JNR, Q34; It’s the vernal equinox at the north pole. which of the following stars can be seen? (8% correct)
  - Everyone happily went to pick Polaris, but did you remember that its sunrise too?

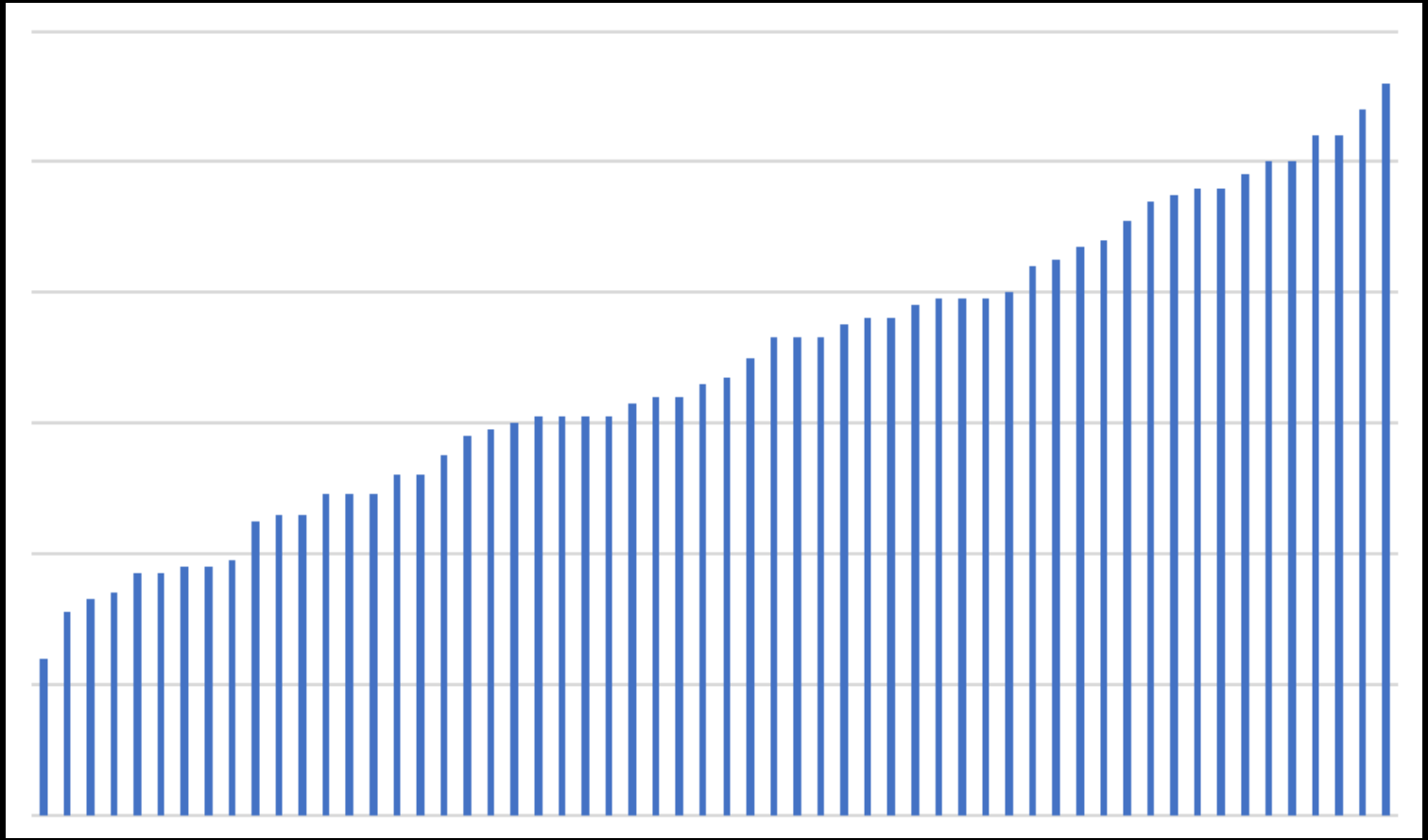
- SNR: tie between Q4 and Q30 (10% correct)
  - Q4: …What is the minimum velocity of the asteroid so that the planet will escape the gravitational field of the star…
  - Q30: Where can we see the two brightest stars (Sirius and Canopus) rise at approximately the same time?
    - If you go out at night: the answer is a latitude close to SG!

MCQ (Most Blanks)

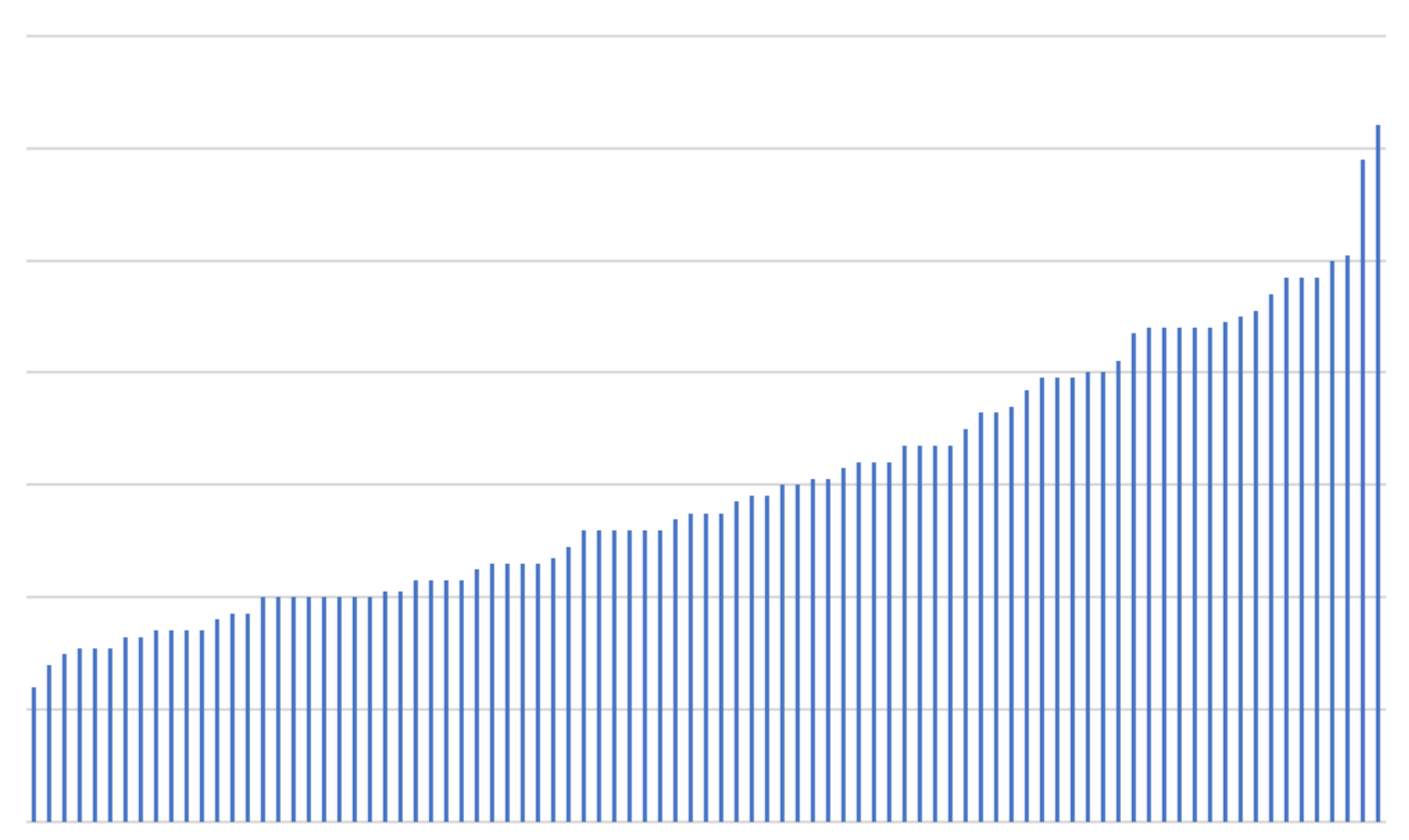
- JNR: Tie between Q1 and Q26 (33%)
  - Q1: …the right ascension of the Pleiades cluster is approximately…
  - Q26: … what is the apparent magnitude of the dimmest star observable by the telescope?

- SNR: Q18 (37%)
  - …If a telescope has limiting magnitude of +16.16 mag because 20% of incident radiation is blocked, what is the real diameter of the telescope?

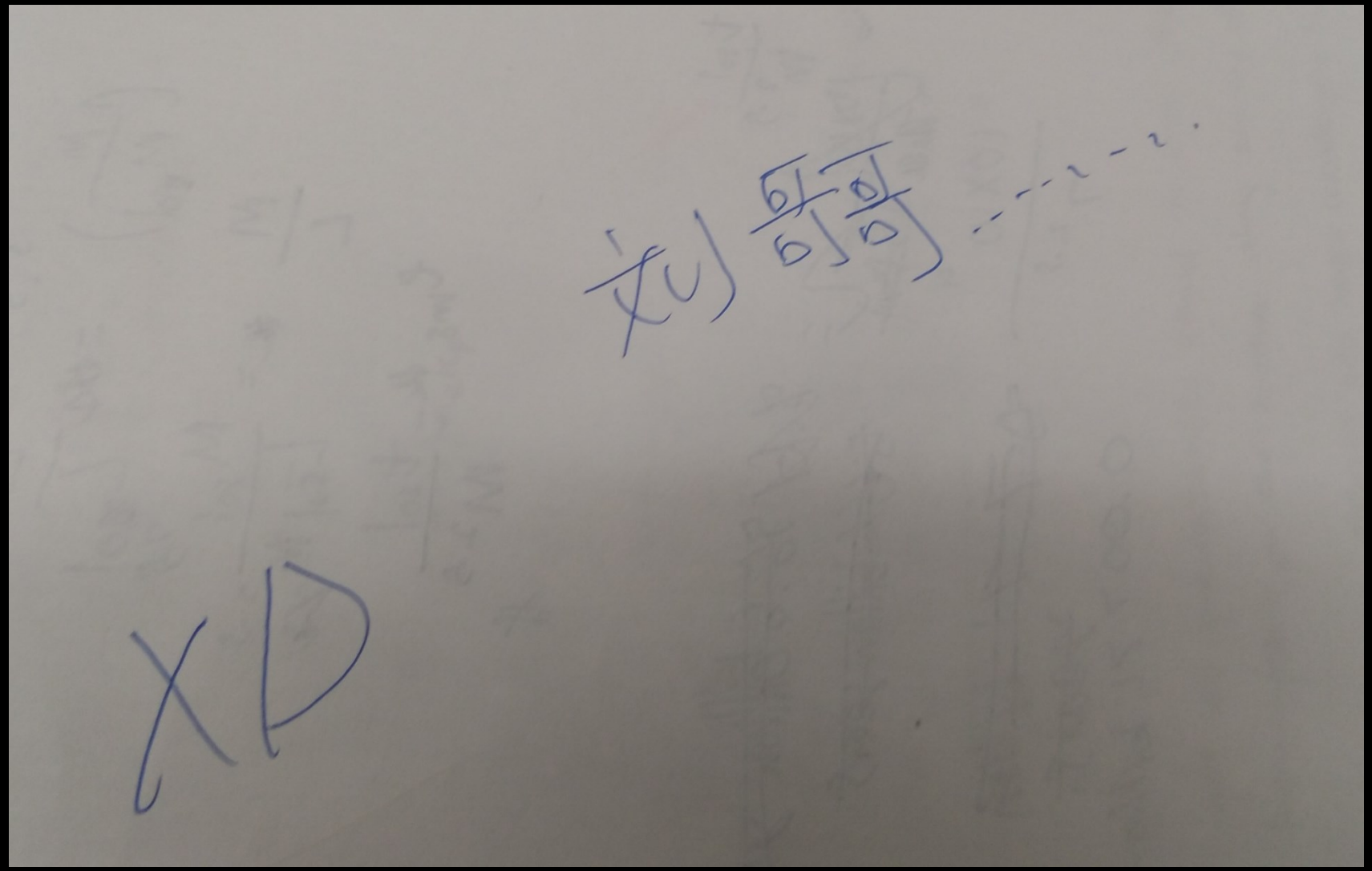
JNR MCQ Scores (Mean = 68.1, SD = 22.1)



SNR MCQ Scores (Mean = 59.8, SD = 22.7)



SNR DRQ



Despite the time extension, teams ended up praying to QMs for mercy

Q1: AGN

Goal of the Question

- Inform students about such an interesting object that is being discussed in current research
  - Remaining open to continuous learning
- Interpreting spectrum provided
  - Gathering data through all senses
- Thinking about the rationale behind certain calculations
  - Thinking about thinking

What happened?

爆炸!!

My Mistakes

i) Which region(s) of the Seyfert galaxy do the Hβ transition line the O III **primary transition line** lines originate from? Hence or otherwise, compute the upper and lower bound of the FWHM and the width lengths using the appropriate radial velocities. [3 marks]

xi) Following which, we may check for mass loss by calculation of what is known as the Eddington limit, for beyond this limit, mass loss occurs for a spherically symmetric object in equilibrium. Hence or otherwise, use supporting calculations to determine if there is any possibility that the black hole region is losing mass. You are given that the Eddington Limit is $L_{ED} \cong 1.5\times10^{31}\frac{M}{M_{\odot}}L_{\odot}$ W for the supermassive blackhole. [3 marks]

Common Mistakes

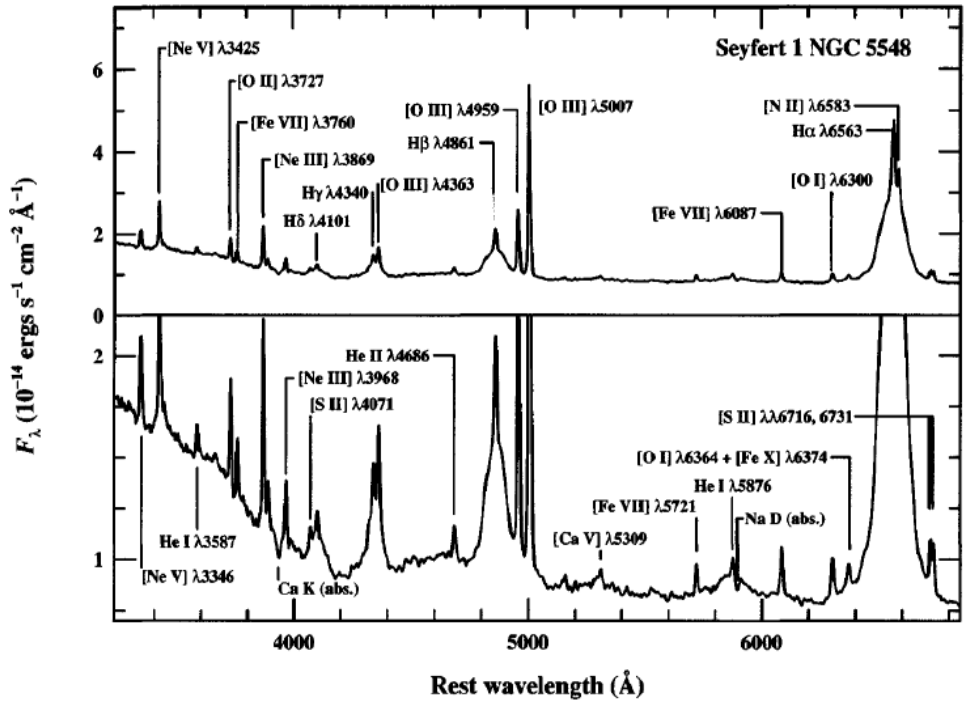


Figure 1 *The optical spectrum of the Seyfert 1 galaxy NGC 5548. Prominent broad and narrow emission lines are labelled, as are strong absorption features of the host galaxy spectrum. The vertical scale is expanded in the lower panel to show the weaker features. Note that the transition lines wavelength values provided are measured at rest.*

Doppler broadening!

Common Mistakes

i) Which region(s) of the Seyfert galaxy do the Hβ transition line the O III **primary transition line** lines originate from? Hence or otherwise, compute the upper and lower bound of the FWHM and the width lengths using the appropriate radial velocities. [3 marks]

$$f_{\text{observed}} = f_{\text{source}}\sqrt{\frac{c-v}{c+v}}$$

$$\lambda_{\text{observed}} = \lambda_{\text{source}}\sqrt{\frac{c+v}{c-v}}$$

No one got this right…);

Common Mistakes

ii) Given that the observed spectral wavelength of the O III primary transition line is 5089 angstroms, calculate the redshift for NGC 5548 and hence its distance away from earth. State any assumptions used in your calculations. [3 marks]

$$z = \sqrt{\frac{c+v}{c-v}} - 1 \approx \frac{v}{c}$$

Calculator skills??

(ii) $Z = \frac{5089 - 5007}{5007} = 0.0164$

$Z = \frac{v}{c}$, $v = 0.0164 \times 10^8 \times 3 = 4920000\ ms^{-1}$

$v = H_0 d$, $d = \frac{v}{H_0} = \frac{4920\ kms^{-1}}{67.8} = 72566\ \cancel{Mpc} = 7.26 \times 10^4\ Mpc$

This is too near…

(ii). $z = \frac{5089 - 4959}{4959}$

$= 0.0262$

$0.0262 = \frac{v}{c}$

$v = 2.4786 \times 10^{14}$ ✗ 0

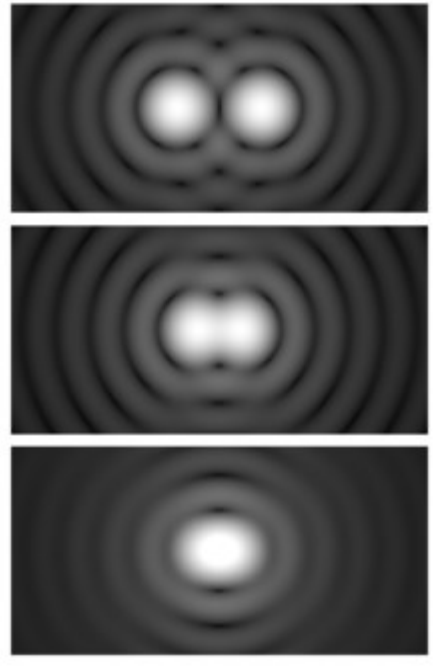
$\boxed{d = \cancel{4.48} \; 2.48 \times 10^{14} \, m}$ less than a ly away???

assume no extinction of light.

Tragic Mistakes

iii) It is known that NGC 5548's core is so luminous such that looking through a telescope it appears to be a star, hence 'quasi-stellar', albeit an unresolved star. By calculating the maximum resolution of the NGC 5548 by the 2.4m Hubble Space Telescope, observed in the visible range, suggest an appropriate upper bound to the diameter of the galactic nucleus in pc. Recall that the visible spectrum lies between 350nm to 700nm. Explain your answer. [2 marks]

$$\sin \Delta\phi_{min} = 1.220 \frac{\lambda}{D}$$



Wrong UNITS!

(iii) $\sin \Delta\phi_{min} = \frac{1.220 \ (750 \times 10^{-9})}{2.4}$

$\Delta\phi_{min} = 0.0000218$

wrong units...

Using Rayleigh resolution criterion, we can calculate the maximum resolvable arcmin.

Using small θ approximation, we can calculate the diameter.

Diameter $= 0.0000218 \times 10^{6} \times 72.2$

$= 1574$ pc

0

If you can’t convince, you confuse the marker!

[42.5] 2 | 75

(iii) 4.54 $\times 10^{-8}$ p.c. Since the radiation emitted by NGC 5548 is in the visible range, similar to the sun, the diameter should be equal to or less than the diameter of the sun.

$$\theta = \frac{1.22\lambda}{D} = \frac{1.22(350)\times 10^{-6}\,mm}{2.4\times 1000\times 10} =$$

0

Inconsistency in thought…

iii) $\sin\theta = \frac{1.22\lambda}{d}$

~~$\theta =$~~

Smaller λ, better resolving power

upperbound $\lambda = 700nm$

~~$\sin\theta = 1.22$~~

$\theta = \sin^{-1}\left(\frac{1.22(700nm)}{2.4}\right)$

$= 0.07''$

By small angle approx,

diameter $= \frac{\theta}{206265} \times$ distance

$= 70.5088'$ $= 70.4325$

$= 70.6$ pc (3sf) $= 70.4$ pc (3sf)

Tragic Mistakes

iv) Calculate the absolute magnitude of NGC 5548 given that it has an apparent magnitude of 13.3. [1 mark]

$$m - M = 5 \log_{10} \frac{d}{10 \text{ pc}}$$

1+2=4

Absolute mag dimmer than apparent???

iv) $\overset{13.3-M}{\cancel{m=13.3}} = 5\log_{10}\frac{2.4786\times10^{14}}{10pc}$

$m = \cancel{-2.17}\ 28.774 = 28.7$ ✗ 0

At this point in time… start flipping tables…

10 pc

$$13.3 - M = 5 \log_{10}\left(\frac{100}{3.261633 44}\right)$$

$M \approx 5.87$ //

(v) $L \propto V^4$

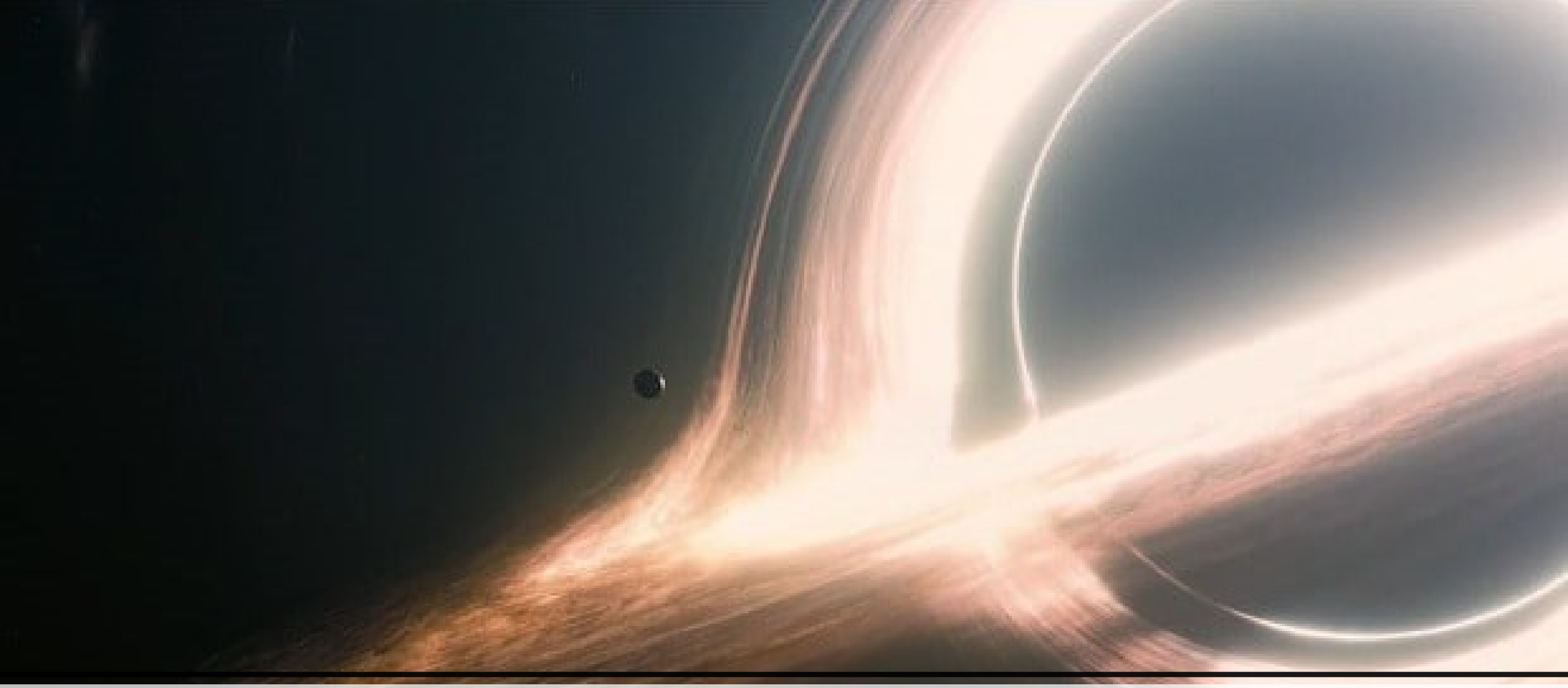
No, as NGC 5548 is a spiral galaxy ~~and~~ hence Tully Fisher relation cannot be used.

(vi) By the third law of thermodynamics, the Stefan-boltzmann law ~~dictates~~ dictates that the angular rotation and relative velocity with reference to the space-time continuum is constant.

Stick whatever *works*

vii) The culprit for the broadening of the spectral lines in NGC 5548 is due to the accretion of matter onto supermassive black holes. Hence or otherwise, calculate the mass of the supermassive blackhole responsible for this object. [1 mark]

$$r_s = \frac{2GM}{c^2}$$



The AstroChallenge Black Hole

I give up…

vii) The culprit for the broadening of the spectral lines in NGC 5548 is due to the accretion of matter onto supermassive black holes. Hence or otherwise, calculate the mass of the supermassive blackhole responsible for this object. [1 mark]

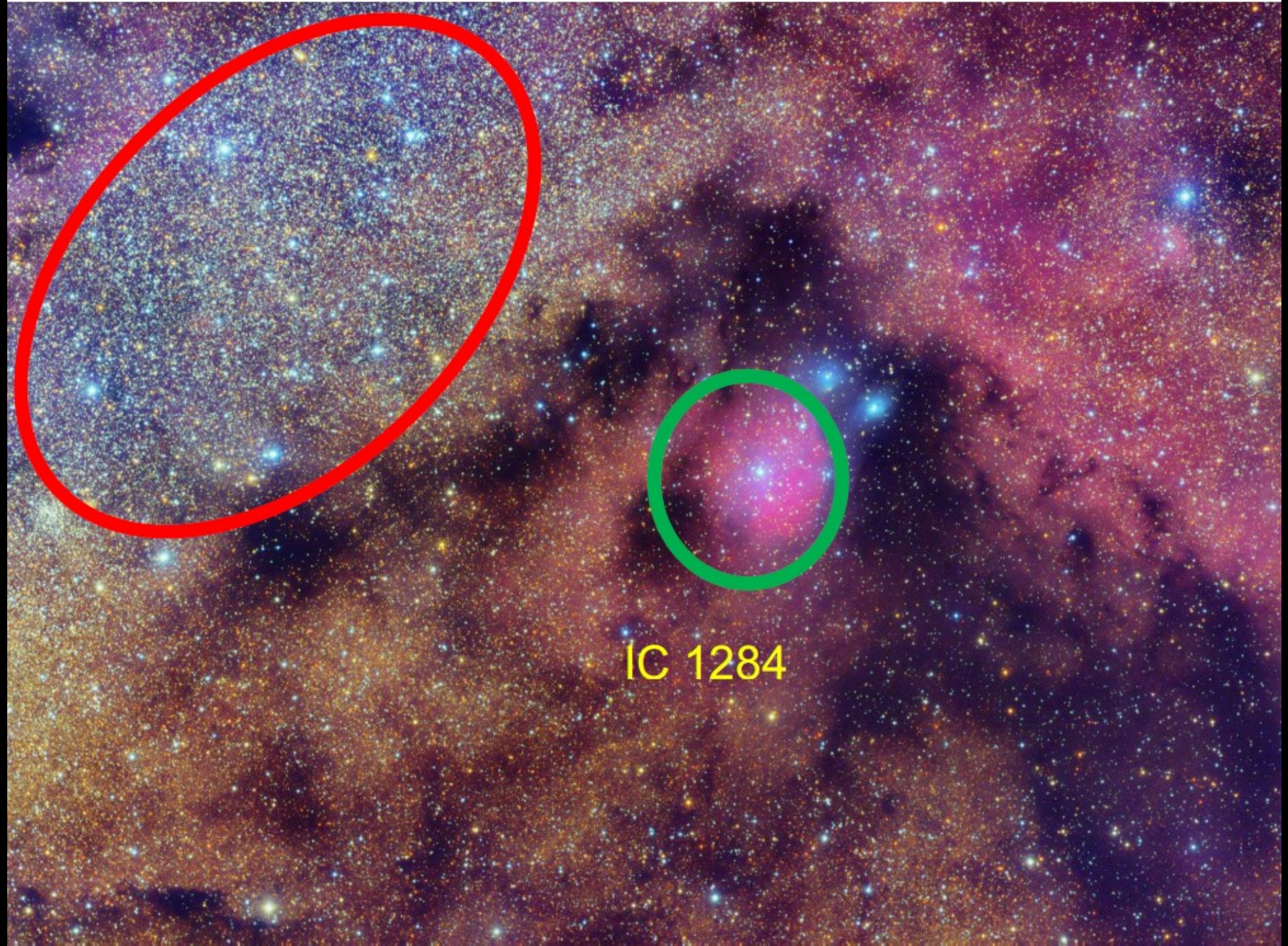
vii) The culprit is the thief that stole my pen.

Q2: An Astronomical Mystery

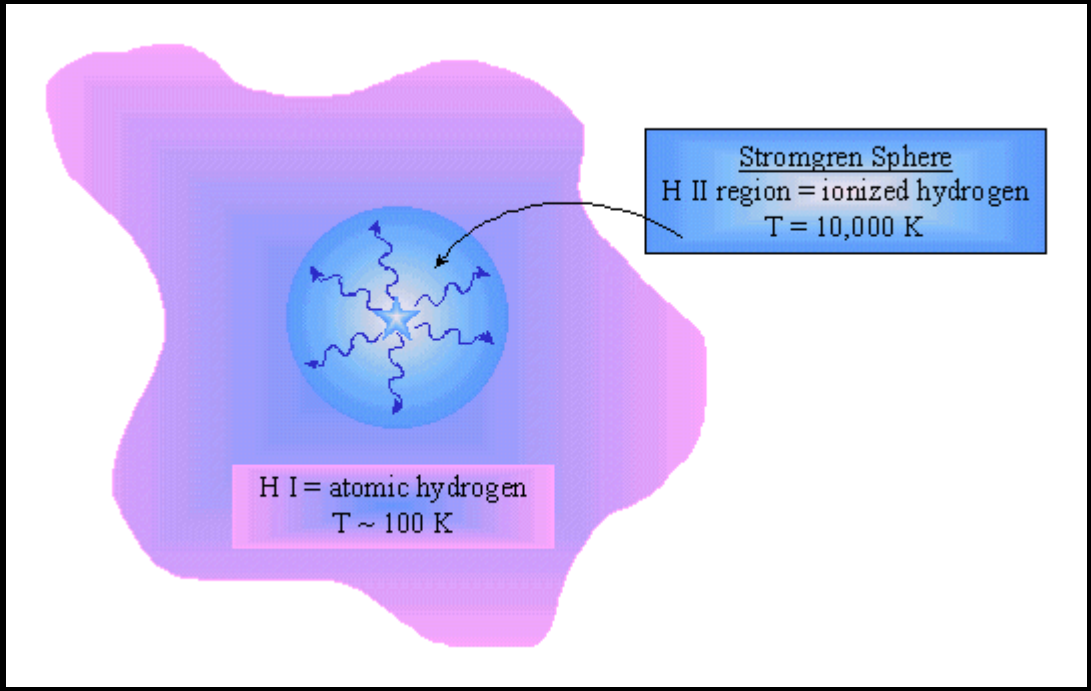
A friendly reminder

We may be “evil”, but we are not crazy.

Your answers <u>must make physical sense</u>


IC 1284

IC 1284: A likely Strömgren sphere



The processes that create these spheres are universal…but reality is messy

Strömgren spheres and reality

Surefire way to be featured in the Post Mortem

1. Read Question

Suppose that HD 167815 supplies Q ionising photons per second to IC 1284. Hence or otherwise, derive an expression for the equilibrium radius of the nebula, R_S. Assume perfect absorption of ionising photons. [2 marks]

2. Fail to press panic button

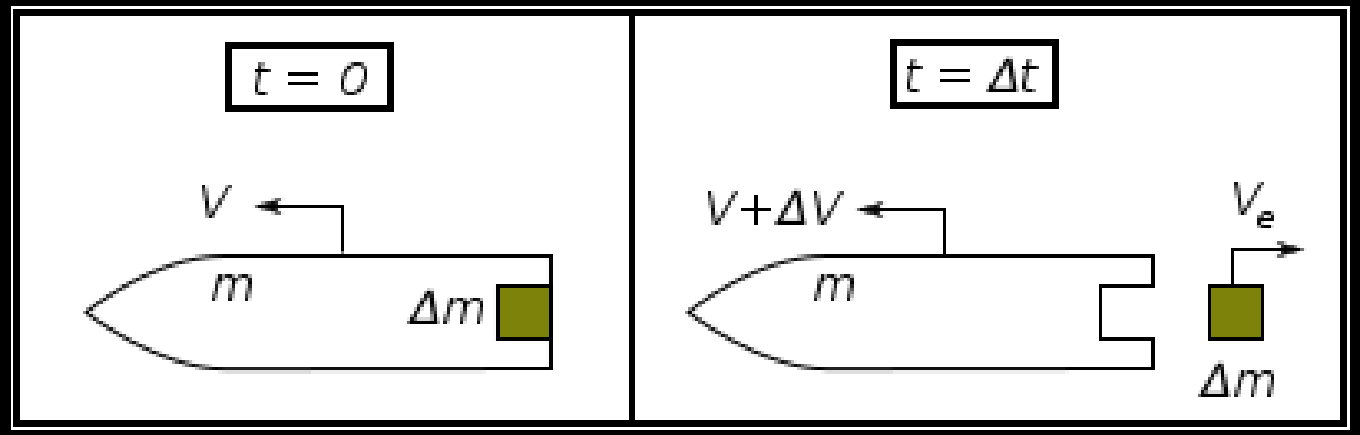
[DON'T PANIC]*

Surefire way to be featured in the Post Mortem

3. Pulls formula from Formula Book that seems remotely related (?!?)

Rocket Equation	$\Delta v = v_{\text{exh}} \log_e \frac{m_i}{m_f}$

4. Can't find anything to feed the formula

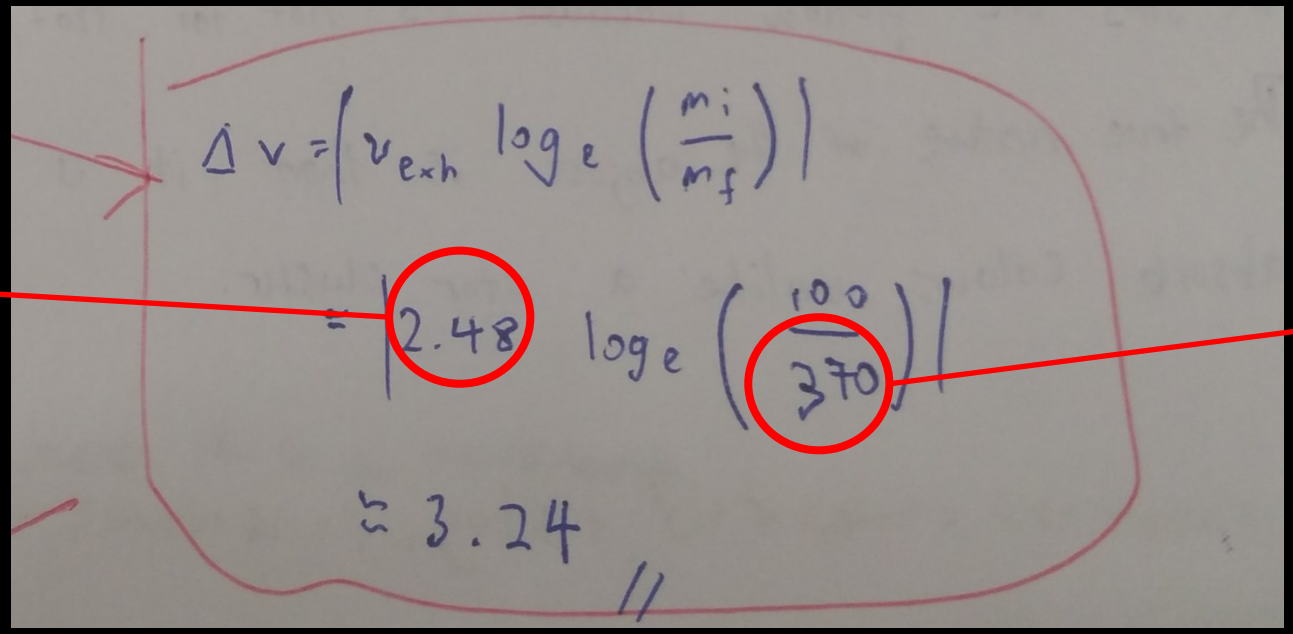


Surefire way to be featured in the Post Mortem

5. Butchers the data to fit the equation…

Rocket Equation	$\Delta v = v_{\text{exh}} \log_e \frac{m_i}{m_f}$

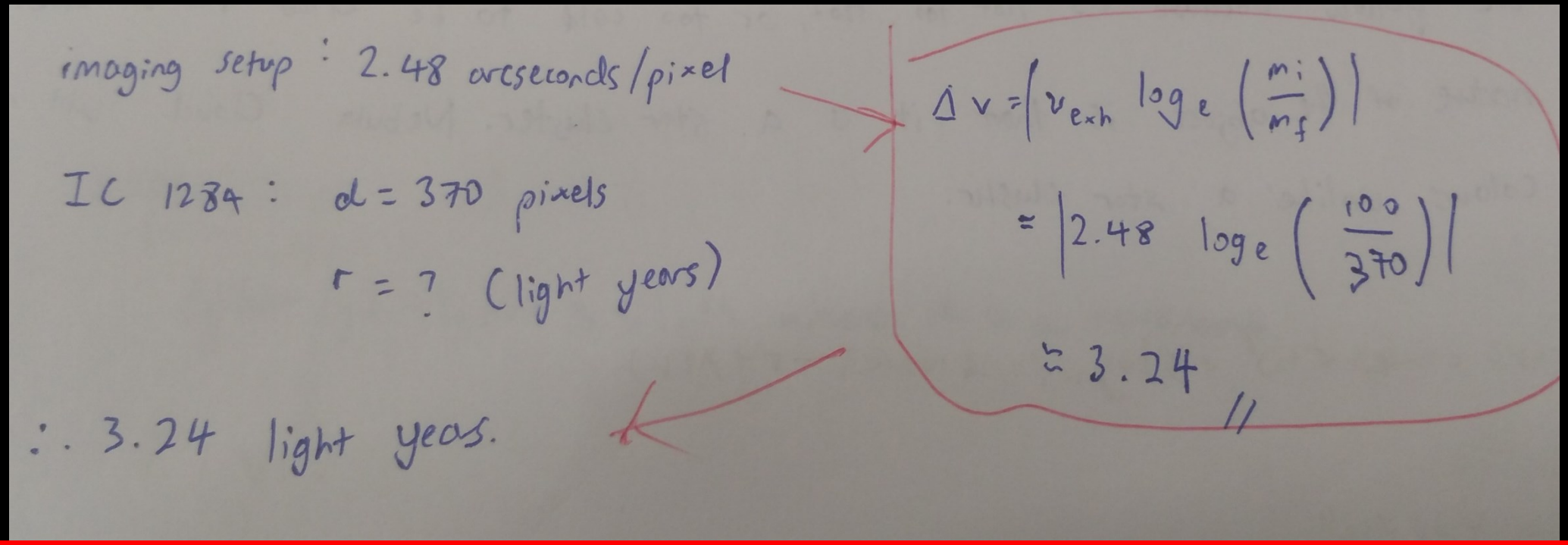
Pixel scale; arcseconds "seen" by each pixel



Diameter of nebula in pixels

Surefire way to be featured in the Post Mortem

6. Picks an appropriate unit to “dress up” the answer



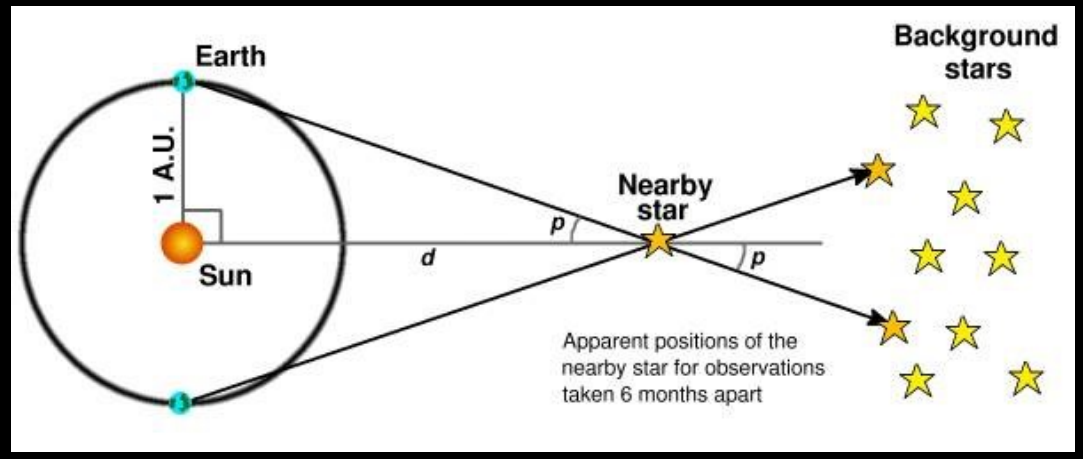
I sincerely thank you for having the decency to give a reasonable answer

Don’t believe me? Let’s do this again! (x2)

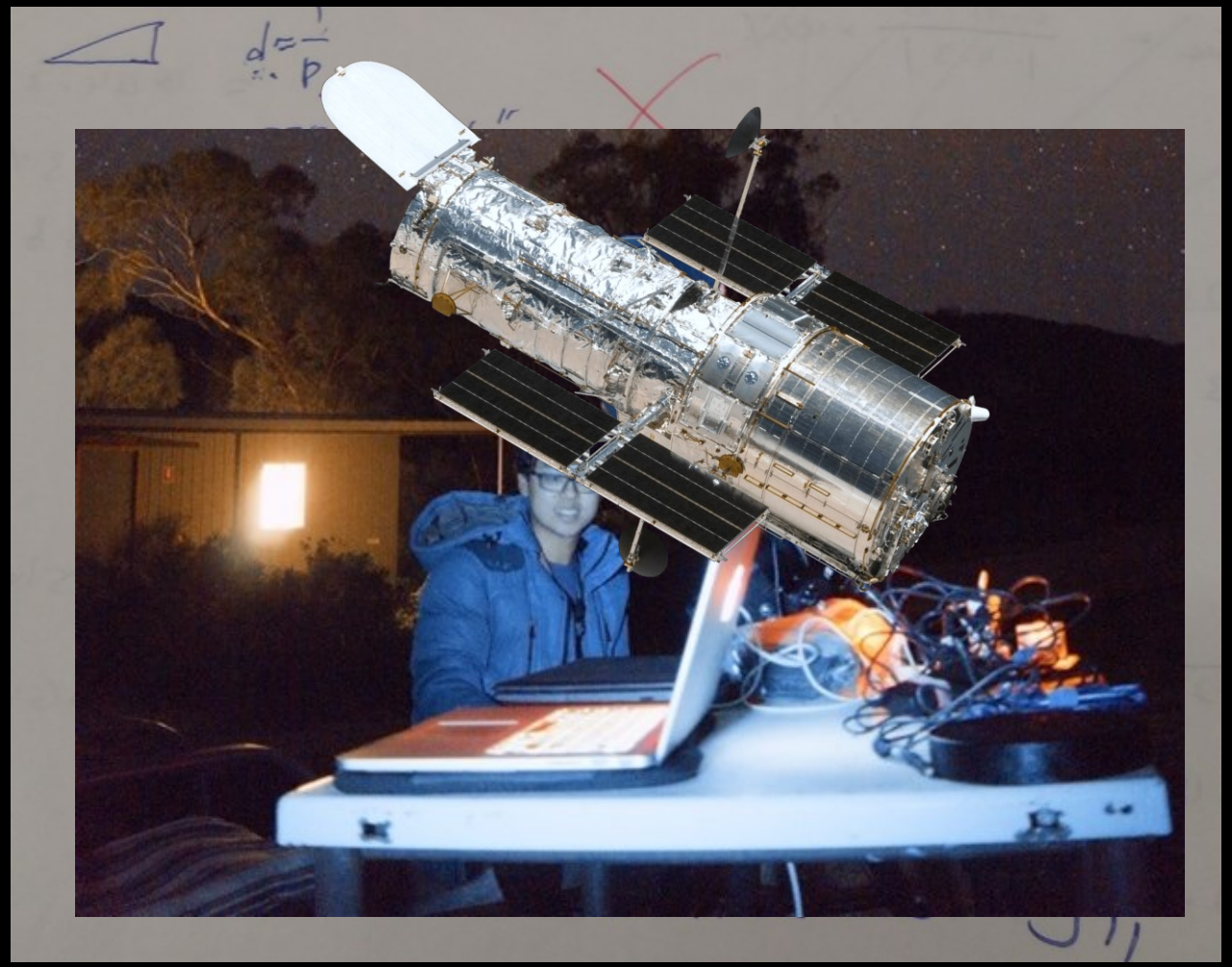
3. Pulls formula from Formula Book that seems remotely related (?!?)

Determining distance d in parsecs using an observed parallax p in arc seconds	$d \approx \frac{1}{p}$

4. Can’t find anything to feed the formula…



After butchering the given values (x2)



- The nebula has a radius of 1125 AU?
- Semi-believable….

Horrific abuse of units (x3 x4)

370 pixel = 917.6 arcsec = 2991.376 LY

= 2990 LY

?

radius = 1500 LY

370 × 2.48 = 917.6 arc sec radius = $\frac{1}{2}$ × 917.6 = 458.8 arc se

radius = 458.8 × 3.26163344 = 1496.437422 ly = 1496 ly

What’s 1500 ly between friends?

The Tarantula Nebula, the most active star forming region in the Local Group

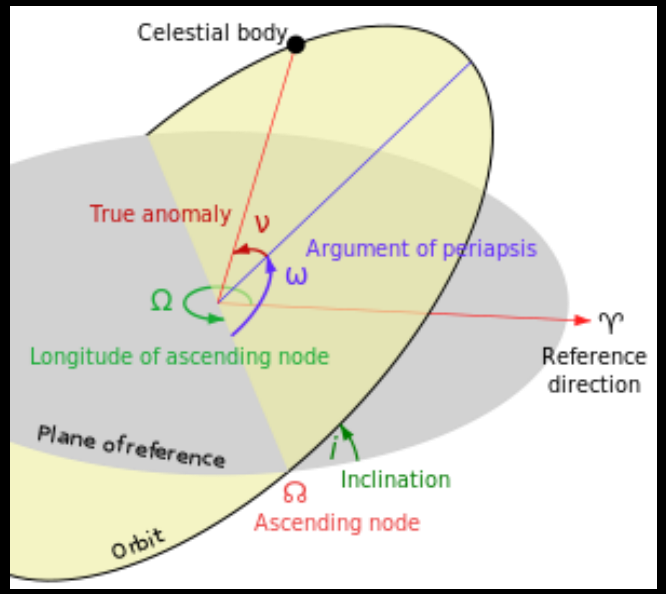
<

Don’t believe me? Let’s do this again! (x5)

3. Pulls formula from Formula Book that seems remotely related (?!?)

Keplerian orbital ellipse as a function of angular deviation from periapsis	$r = \frac{a(1-\epsilon^2)}{1+\epsilon\cos\phi}$

4. Can’t find anything to feed the formula…



After butchering the given values (x5)

(vii) $r = \dfrac{370\,(1-(2.48)^2)}{1+(2.48\cos(0))}$

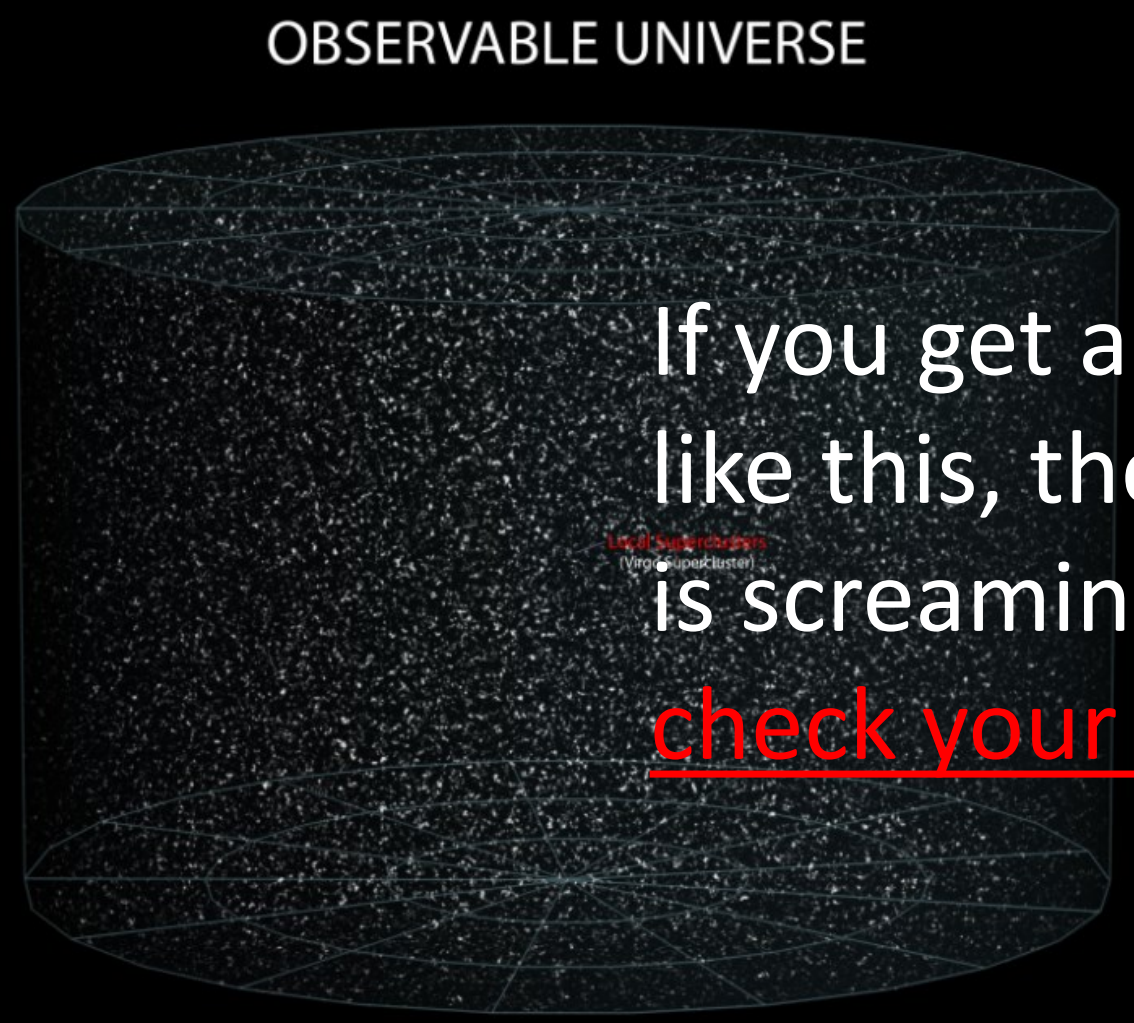
$r = \dfrac{1905.648}{3.48}$

$r = 547.6$

r in light years $= 547.6 \div 9.4605284 \times 10^{15}$

$= 5.79 \times 10^{16}$

What does 10^{16} light years mean?



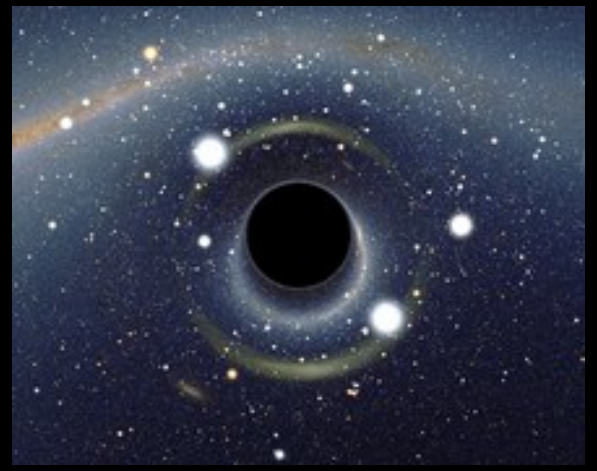
If you get answers like this, the universe is screaming at you to check your work.

Don’t believe me? Let’s do this again! (x6)

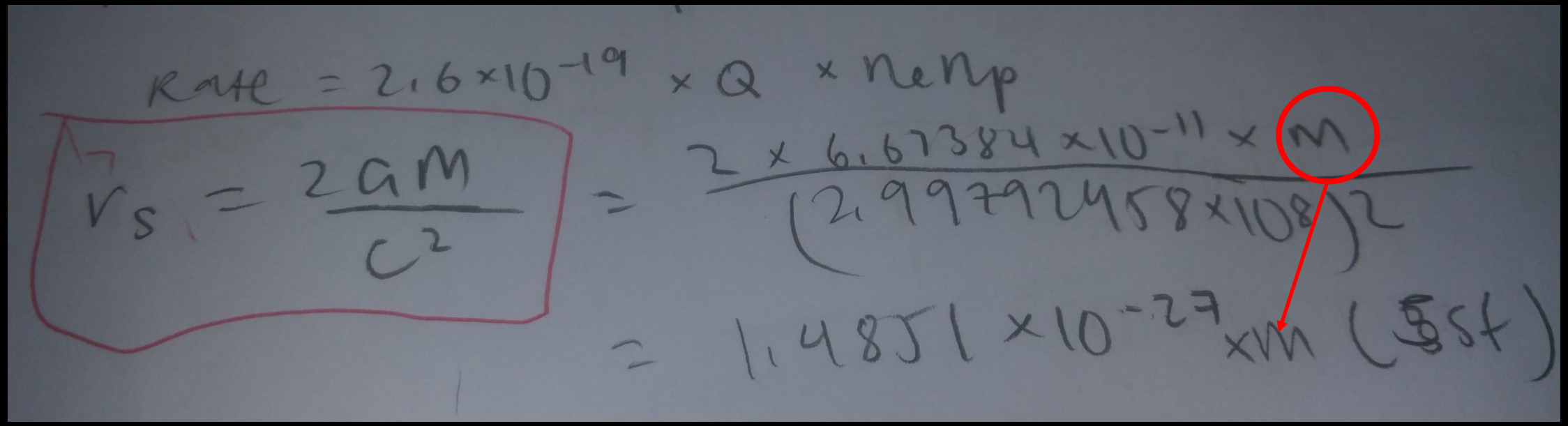
3. Pulls formula from Formula Book that seems remotely related (?!?)

Schwarzschild Radius	$r_s = \frac{2GM}{c^2}$

4. Can’t find anything to feed the formula…



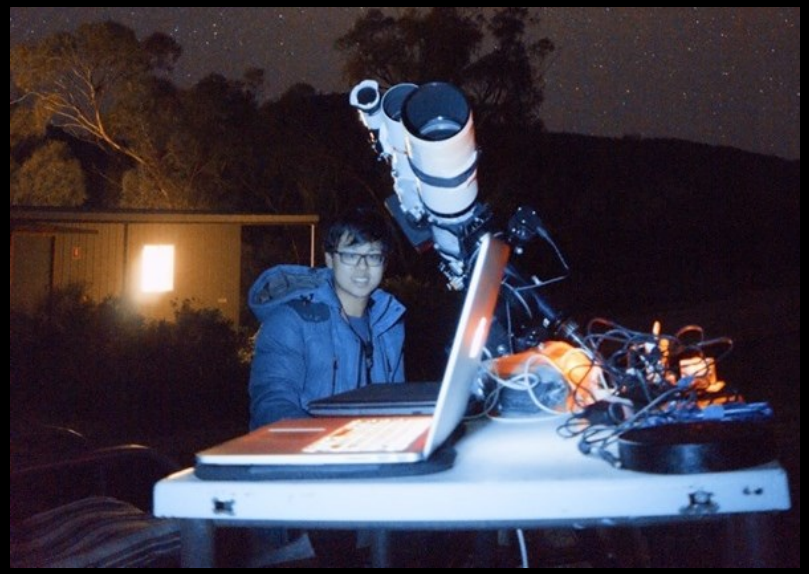
Surefire way to be featured in the Post Mortem



Let us take a moment to admire this masterpiece of math

So much winning….

1. This emission nebula is a black hole that's smaller than **<u>an atom</u>**



2. Ivan has a particle accelerator that can probe objects smaller than ***<u>neutrinos</u>***

ix) Given that the Hα line has a wavelength of 656.28 nm and around 40% of all recombining hydrogen gas emits Hα, what is the luminosity of IC 1284 in Hα? Express your answer in terms of solar luminosities. [2 marks]

And we aren’t even done yet!

Does this look like a black body?

This is an emission nebula!
It emits light in specific wavelengths only!!!

“Black body” nebula assumption

ix) $\lambda = 656.28\ nm$

↓ 40% recombining H_2 emits H_α

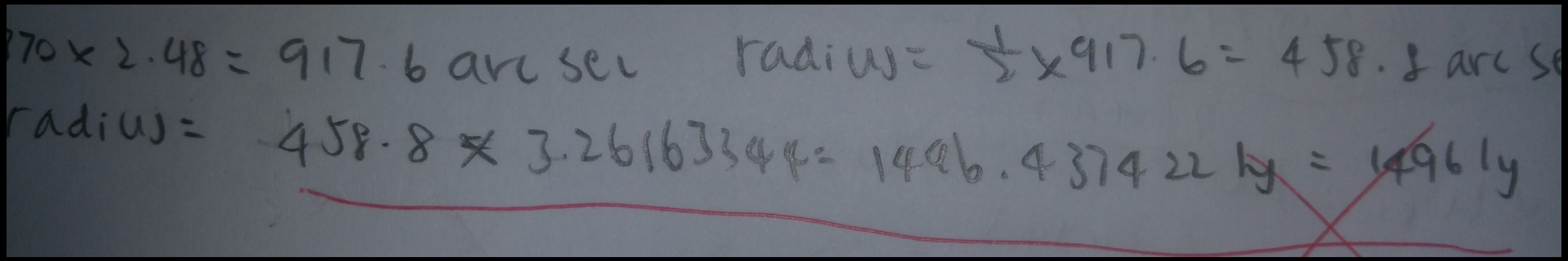
$L = ?$ $(L_\odot)$

$$T = \frac{2.89776829 \times 10^{-3}}{656.28}$$

$$= 0.0000044154 4\ K$$

$$L = 4\pi (0.4)^2 (5.67 \times 10^{-8}) (0.00000$$

$$= 4.33 \times 10^{-29}$$ Lsun



Did you forget me?

“Black body” nebula assumption

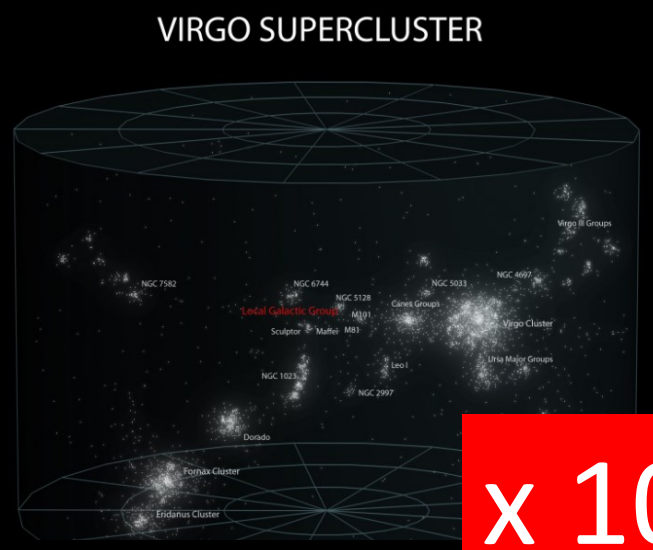
$$28 \times 10^{-9} = \frac{2.89 \times 10^{-3}}{T}$$

$$T = 4403.608216\,K$$

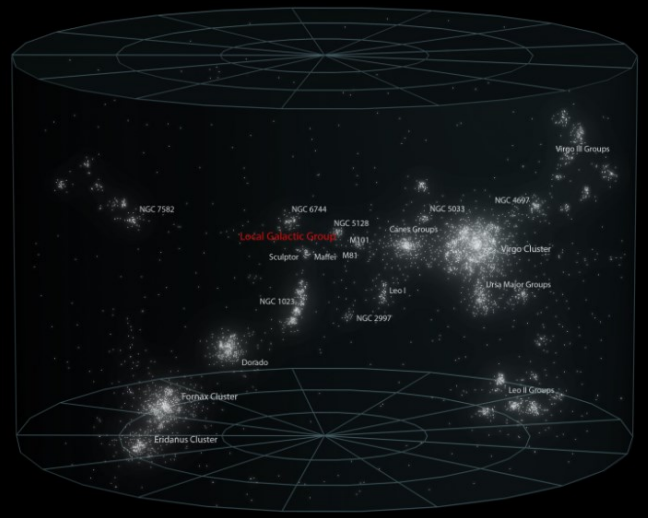
$$L = 4\pi\,(1496 \times 9.4605284 \times 10^{15})^2 \times 5.67 \times$$

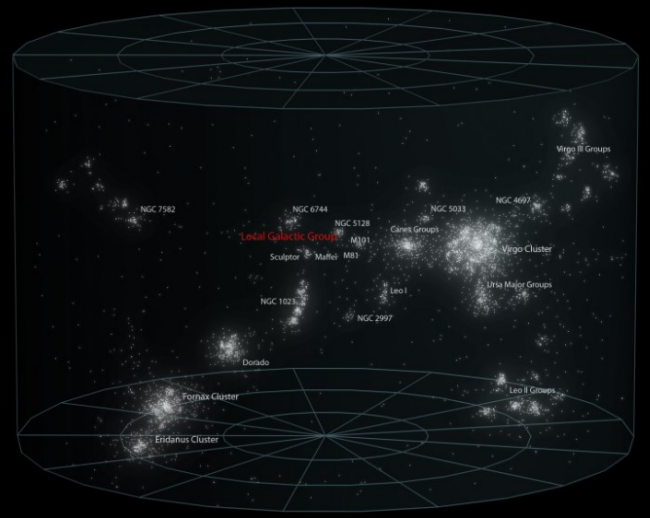
$$= 5.366876367 \times 10^{46}$$ W or L_{sun}

How out of this world is 5×10^{46} W?

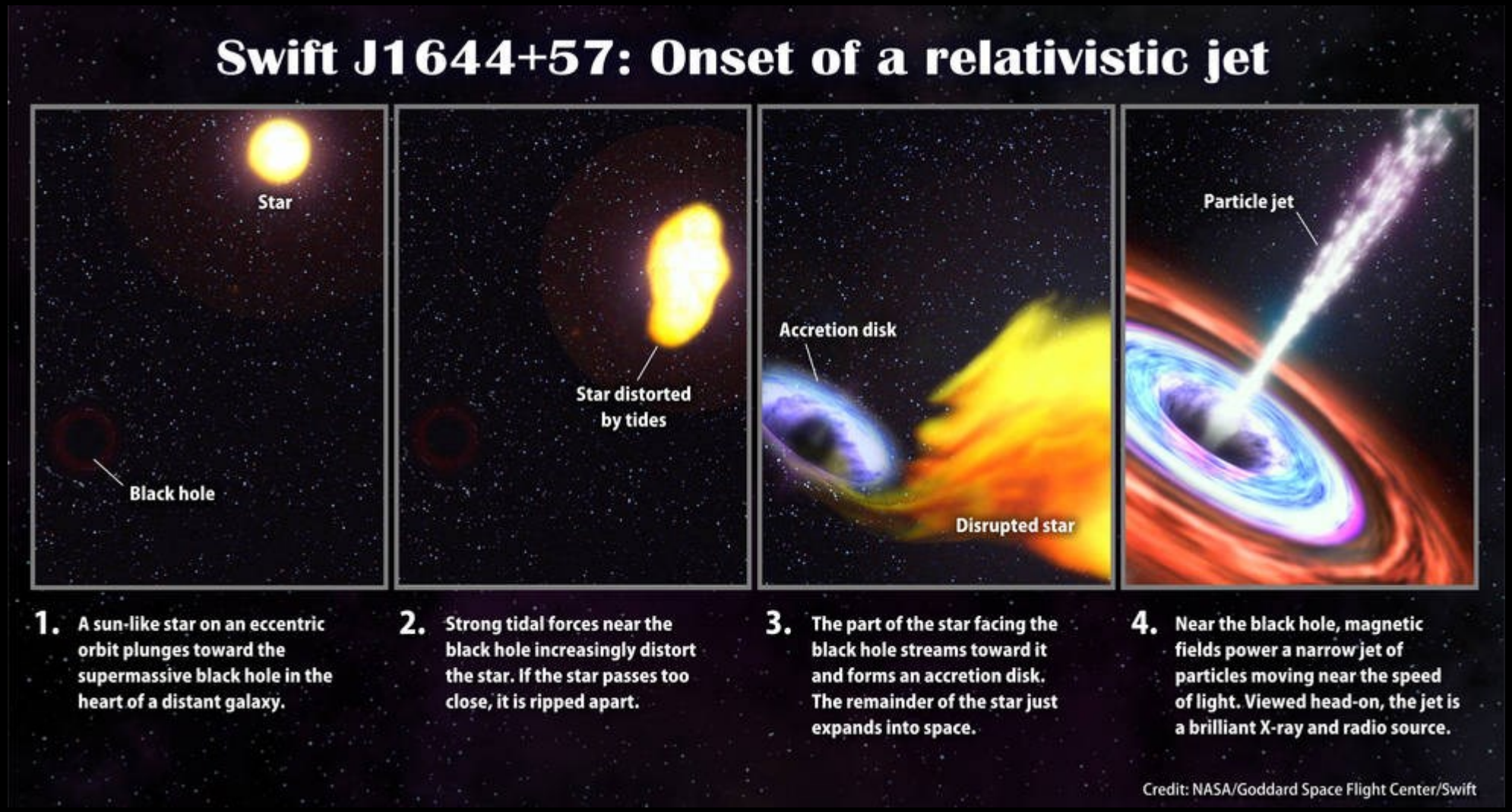


x 10,000 more of this slide

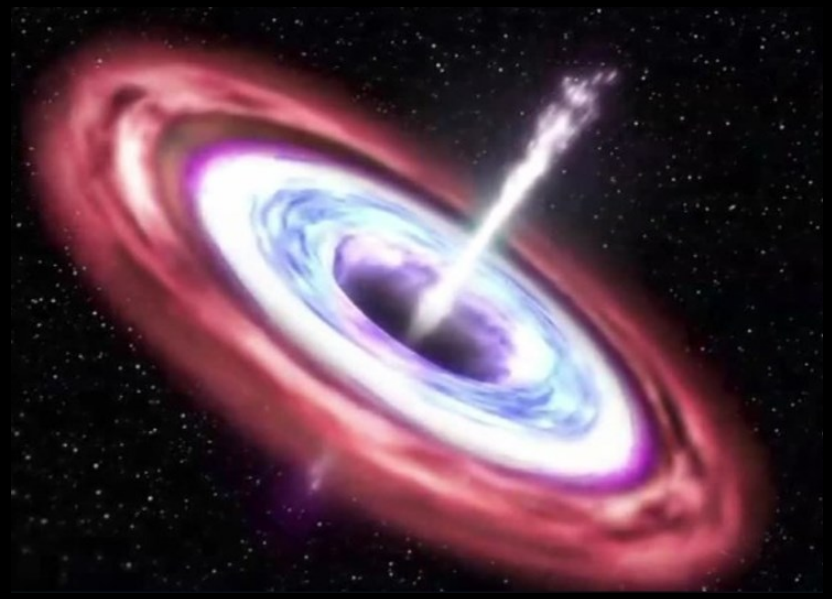




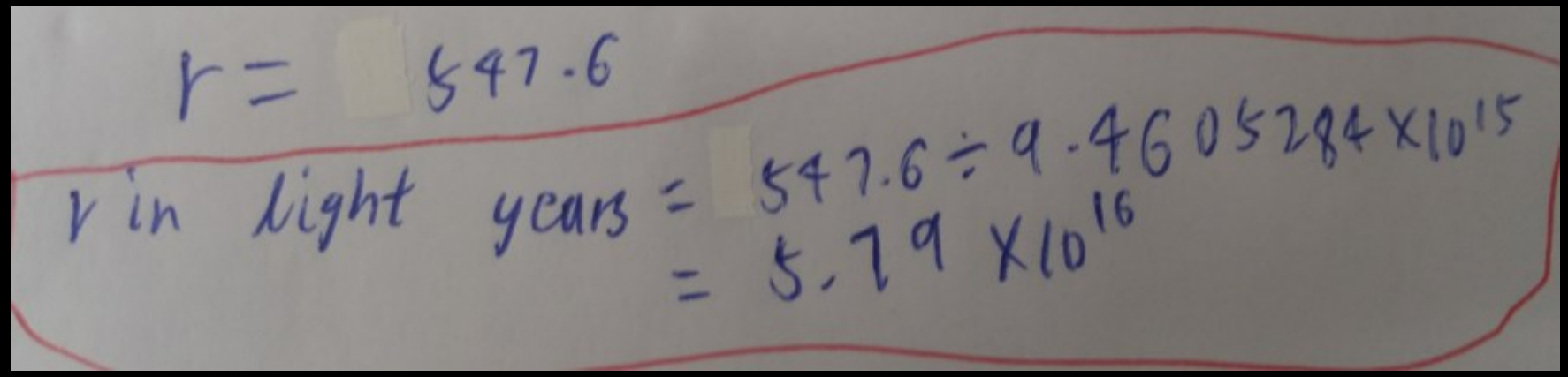
In fact, let us invent a new unit…



= 50x

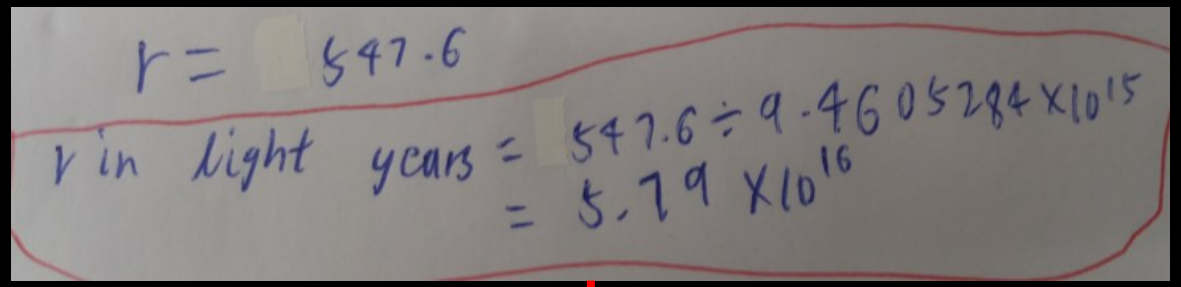


Ooops



Don’t forget me too!

More fun with units!



Get Diameter

Divide by wavelength of light??

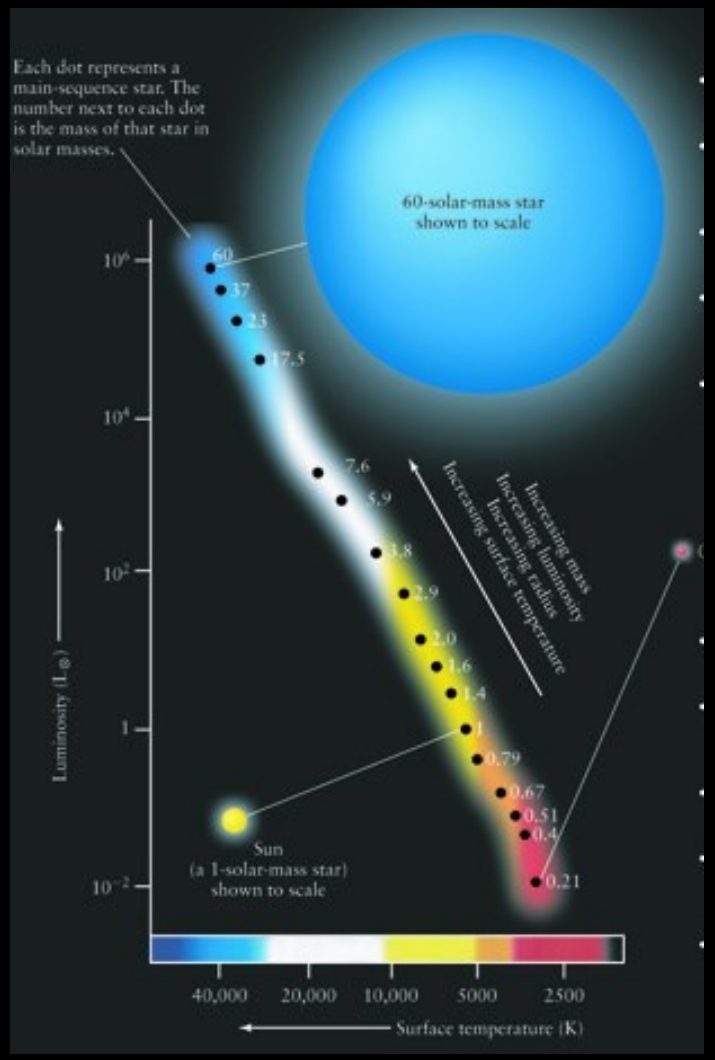
More fun with units

Get dimensionless constant

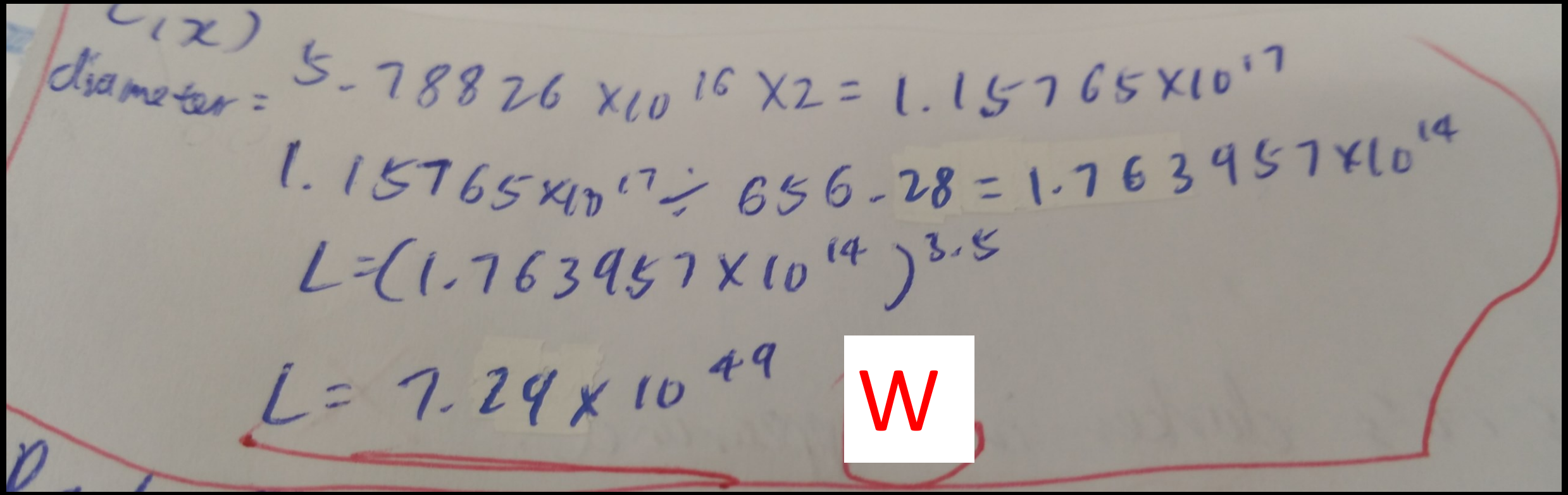
Pulls formula from Formula Book
that seems remotely related (?!?)

Mass-Luminosity Relation for Main Sequence stars	$L \propto M^{3.5}$

Can't find anything to feed the formula…

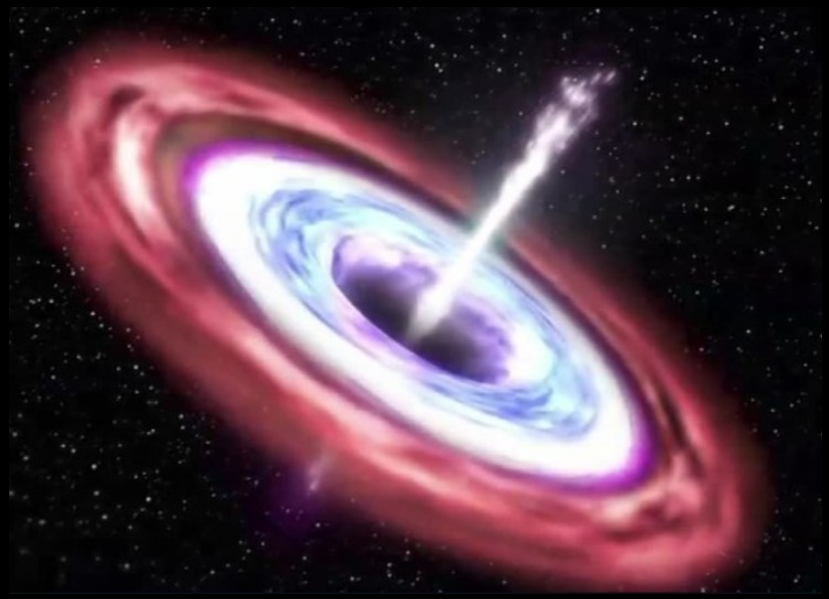


Behold! A masterpiece of perfection!



= ~~50x~~

70,000x



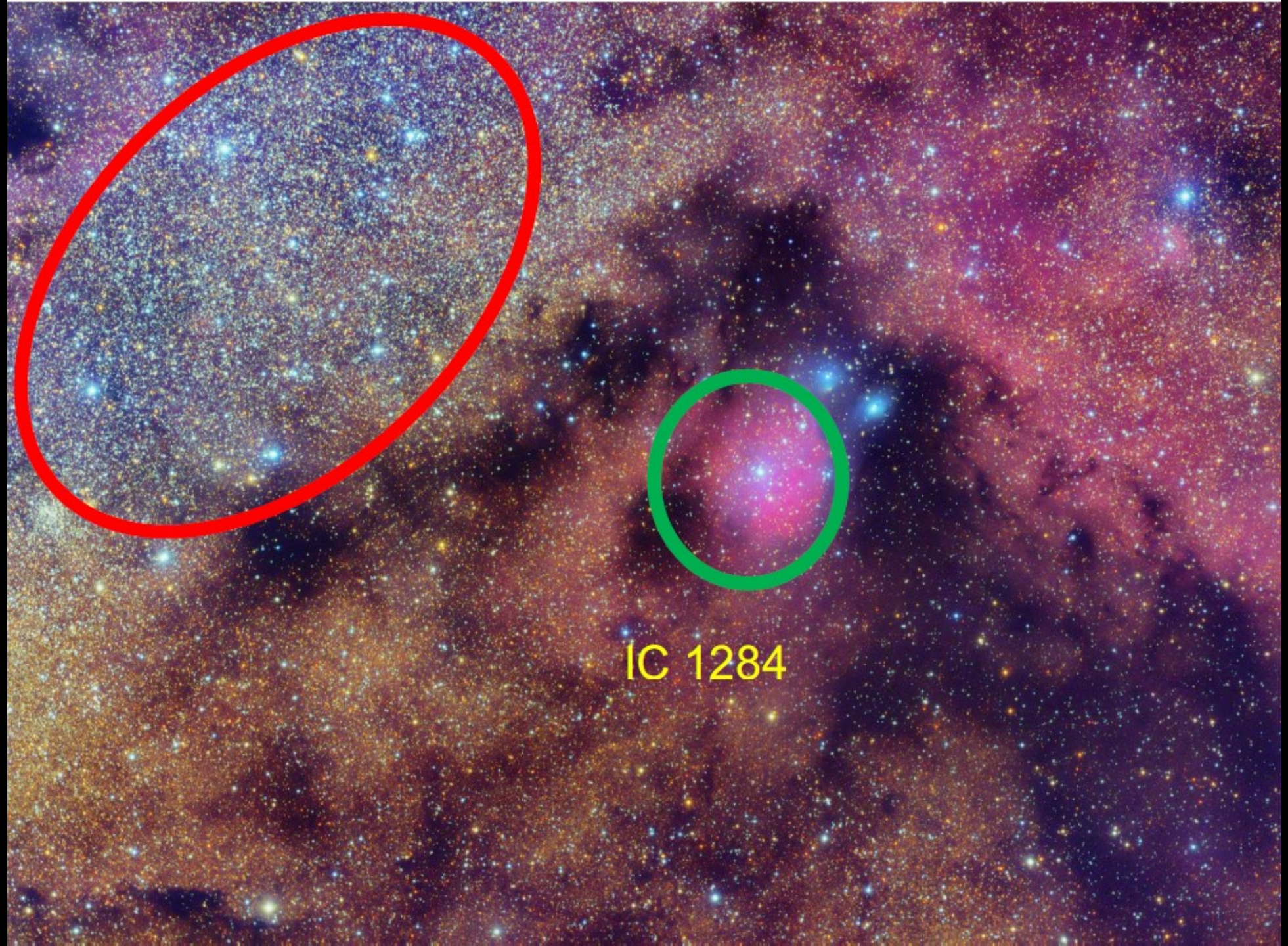

WHEN YOU ARE A STAR...
YOU CAN DO ANYTHING!


such bright
so amaze
wow
shiny
many heat

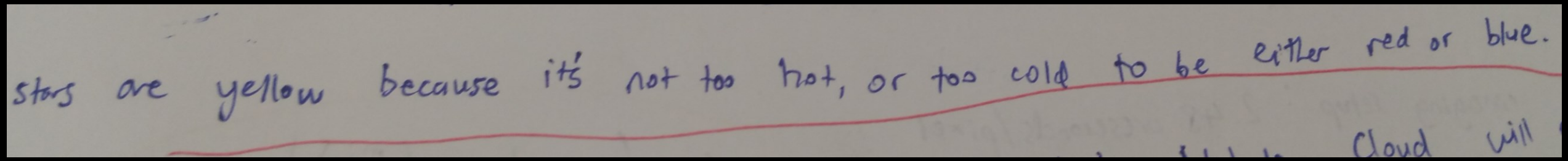
The point of this “showcase”

If you’re lost, PLEASE PLEASE ASK FOR HELP.

Don’t cook up new physics on the fly


IC 1284

Why are the stars so yellow?


stars are yellow because it's not too hot, or too cold to be either red or blue.

This is not what we meant by the Goldilocks zone!

Why are the stars so yellow?

Parallax	2.80 milliarcseconds
Spectral Classification	B1.5III
Apparent magnitude (B)	7.70
Apparent magnitude (V)	7.61
Apparent magnitude (K, near-infrared)	6.957

IDK who should be more insulted here….

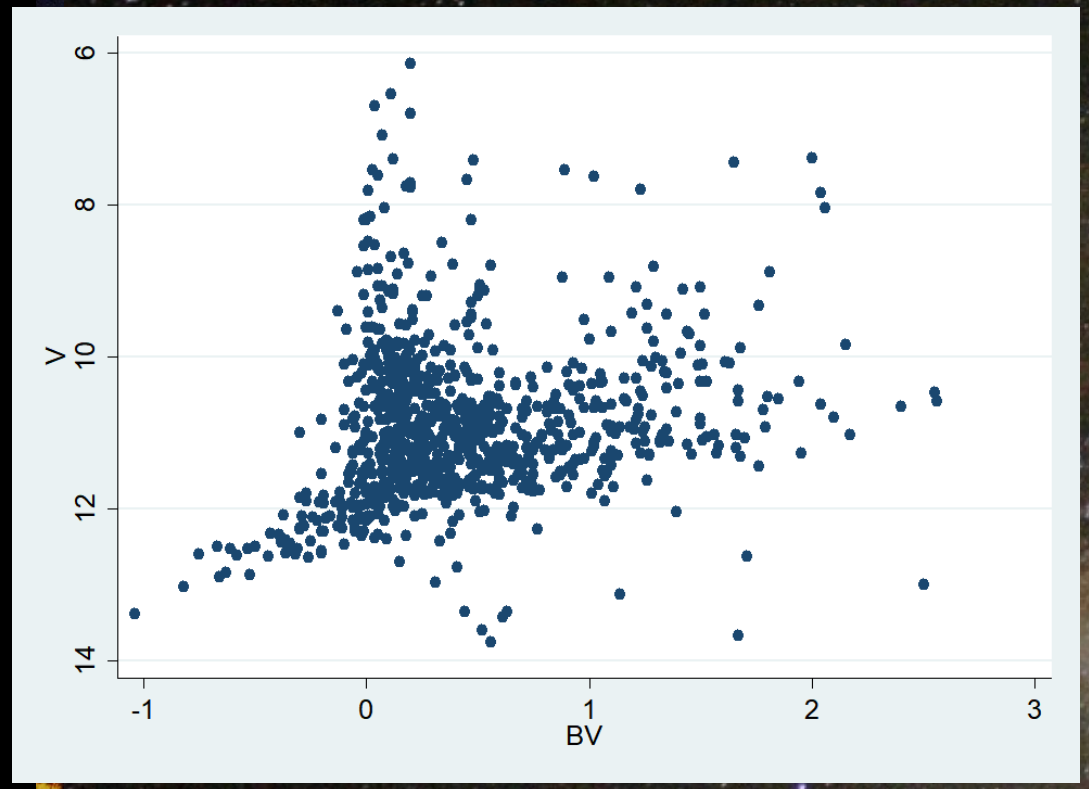
What is the object in the oval?

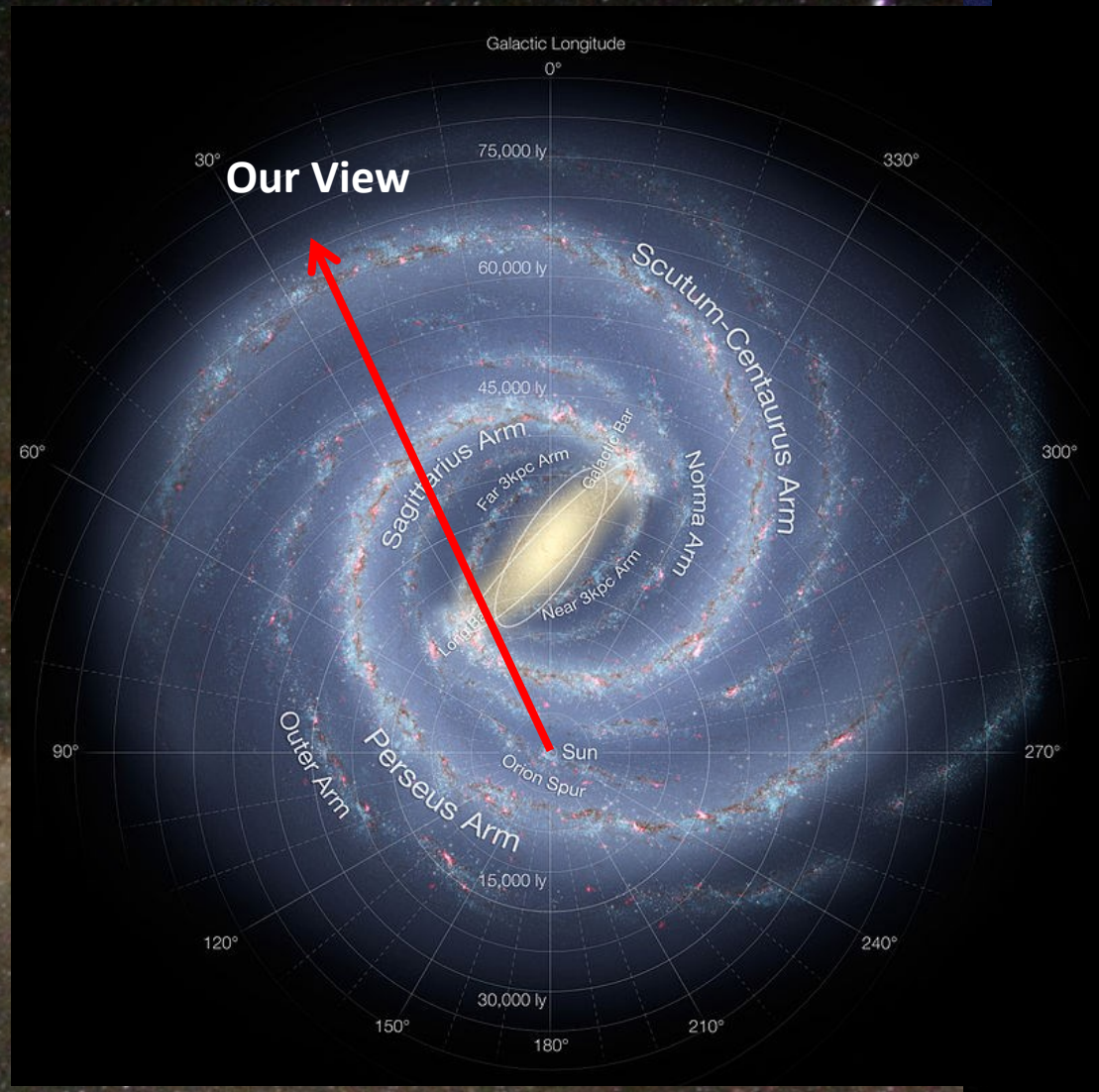
It is a supernova remnant. The central star is probably a neutron star and the reason for its ~~the~~ apparent magnitude being

These are mostly protostars.

ii) The nature of the object in this oval is a supernova. M
0.5 Bv and 11 V. Lowering data is seen at 0 Bv and

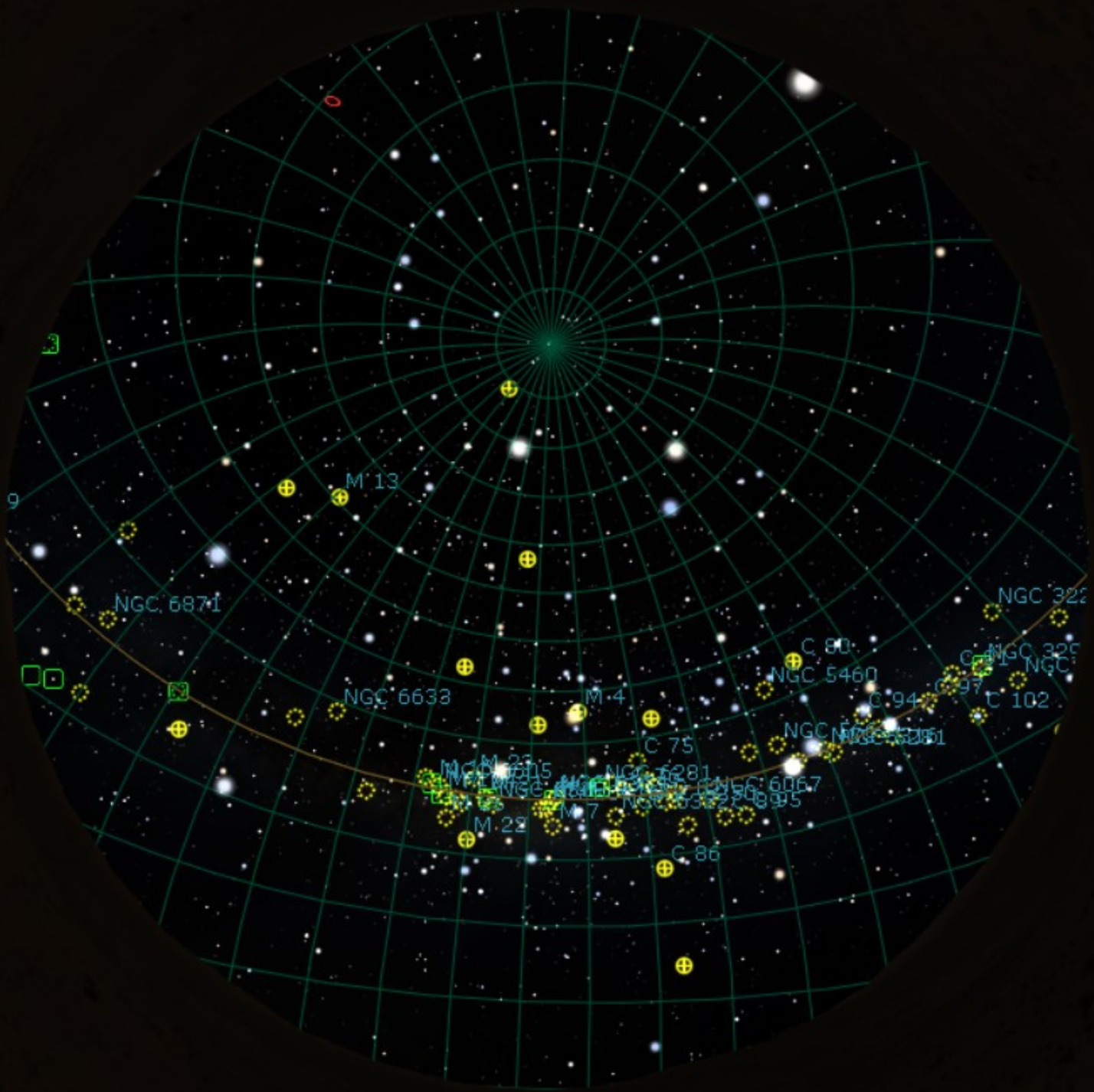

IC 1284

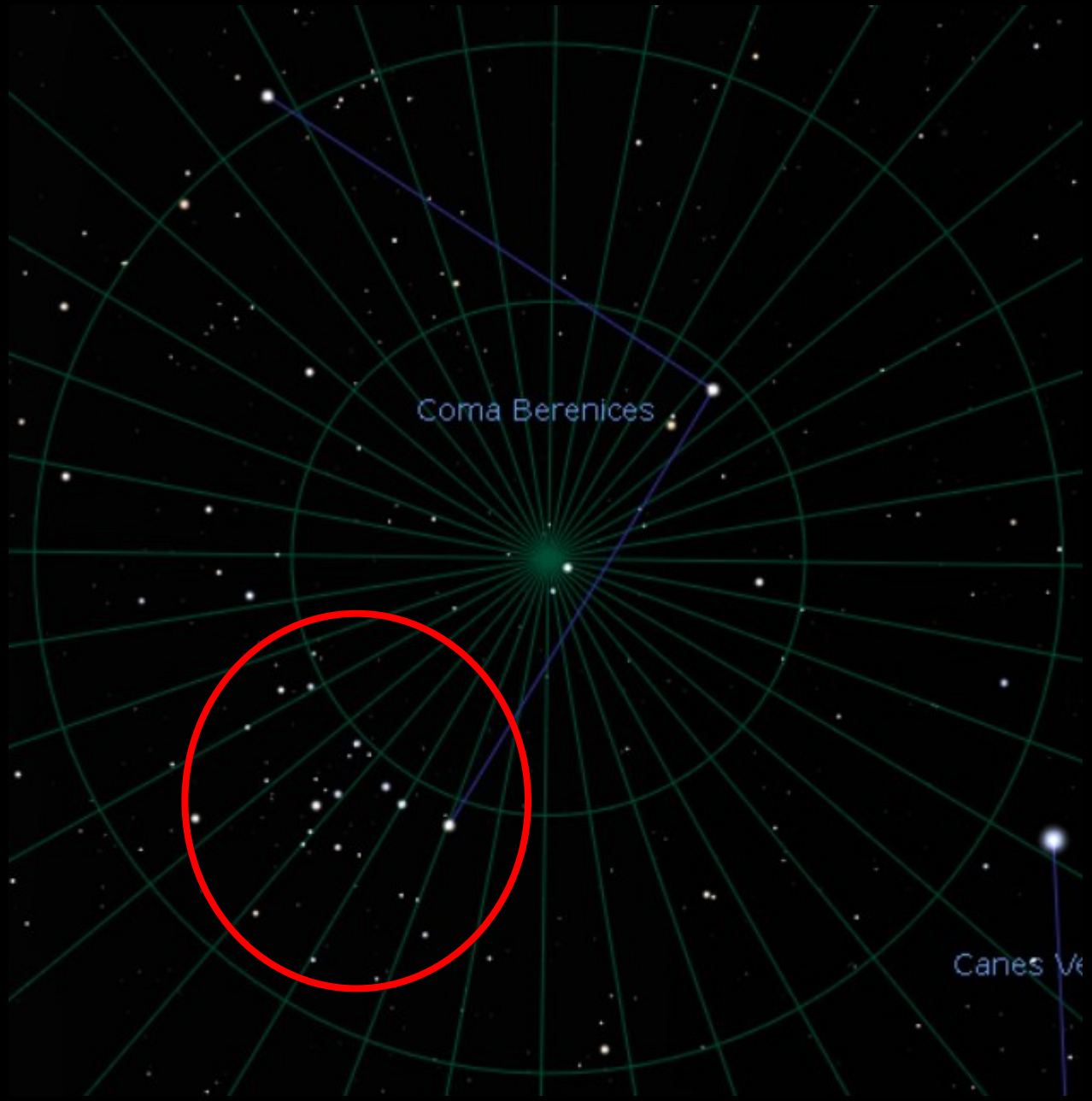

V
6
8
10
12
14
-1
0
1
2
3
BV


Galactic Longitude
0°
30°
330°
60°
300°
90°
270°
120°
240°
150°
210°
180°
75,000 ly
60,000 ly
45,000 ly
30,000 ly
15,000 ly
Our View
Scutum-Centaurus Arm
Sagittarius Arm
Far 3kpc Arm
Galactic Bar
Norma Arm
Near 3kpc Arm
Local Bubble
Outer Arm
Perseus Arm
Sun
Orion Spur

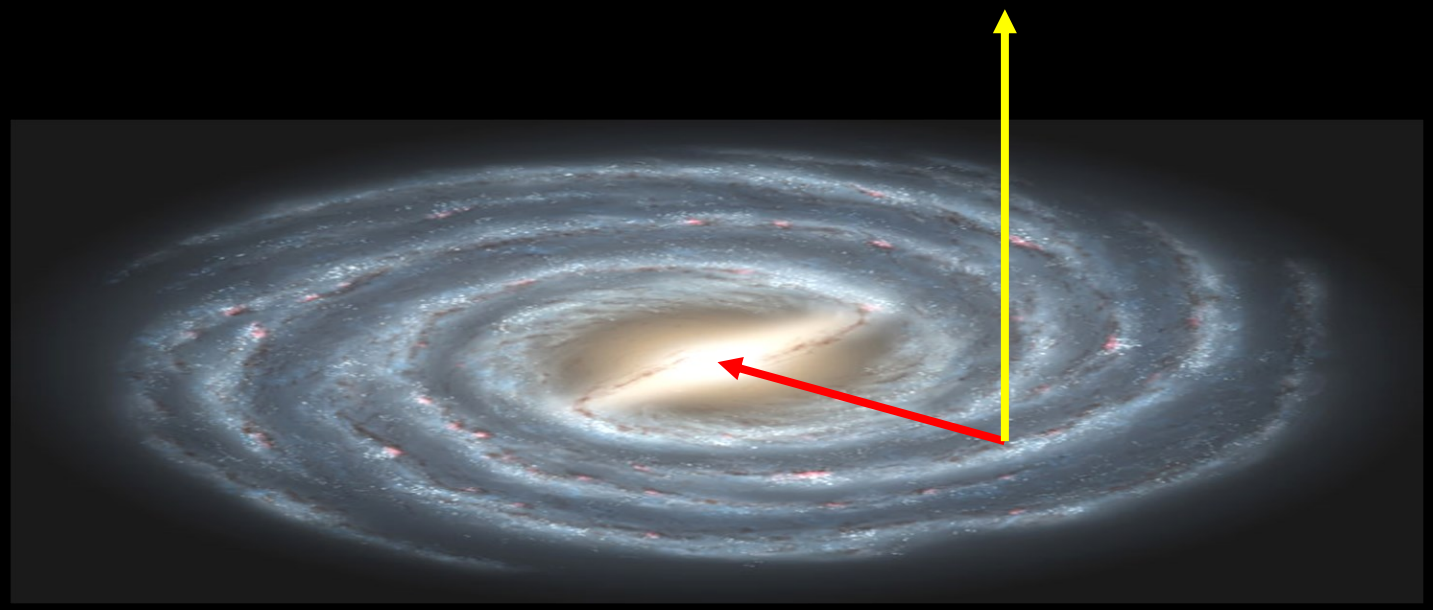
Q3: In a Coma over Coma

Seems like the question was certainly coma-inducing!

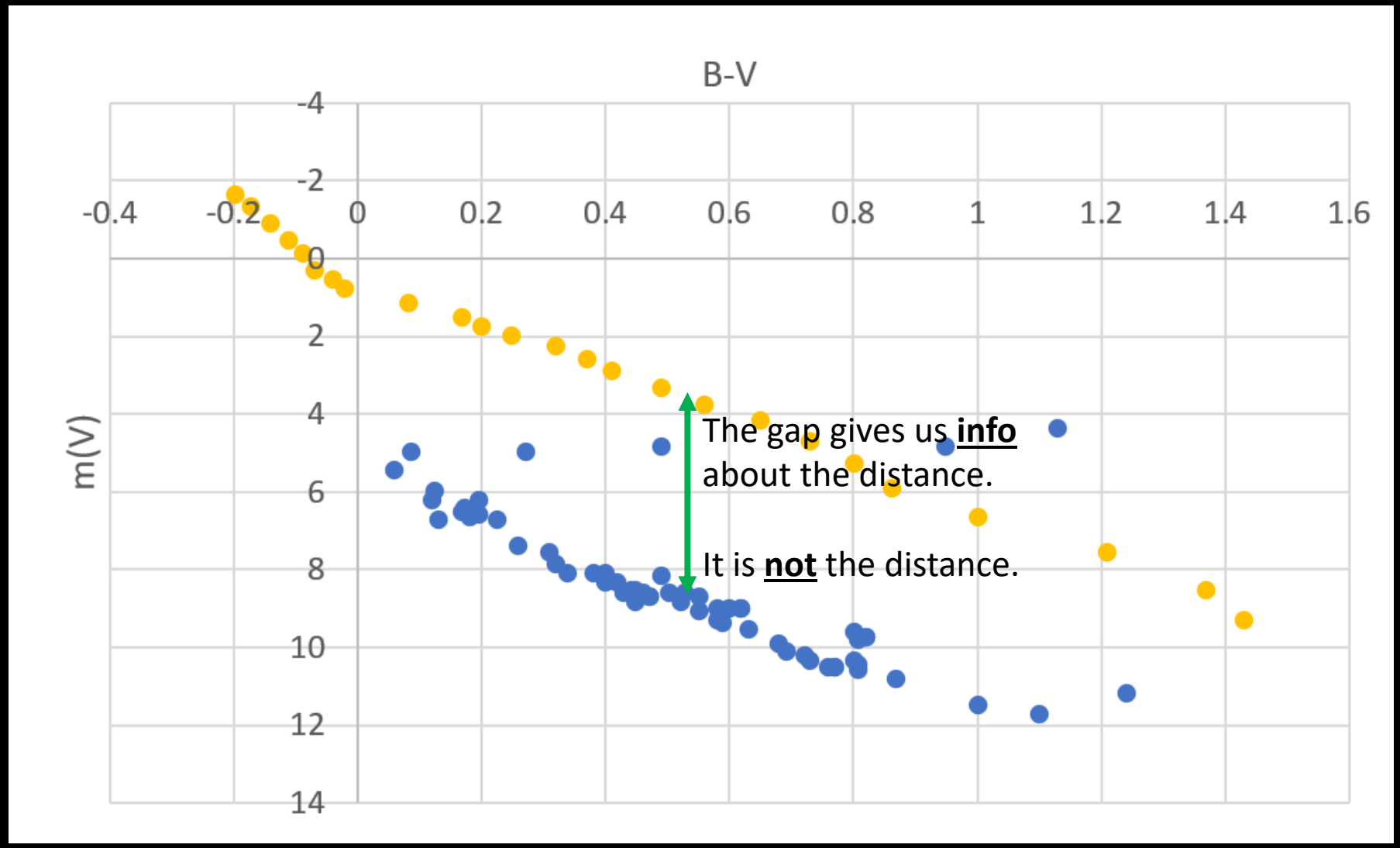

M 13
NGC 6871
NGC 6633
M 4
C 80
NGC 5460
C 94
C 102
C 75
M 22
M 7
C 86


Coma Berenices
Canes Ve

Translating the night sky in 3D



Finding the distance to a cluster



To the team that wrote this…

Approximate distance to Coma Star Cluster $= \frac{4.7 + 4.6 + 4.5 + 5.1}{4} \times 10^{-5}$

(diagram on pg 15)

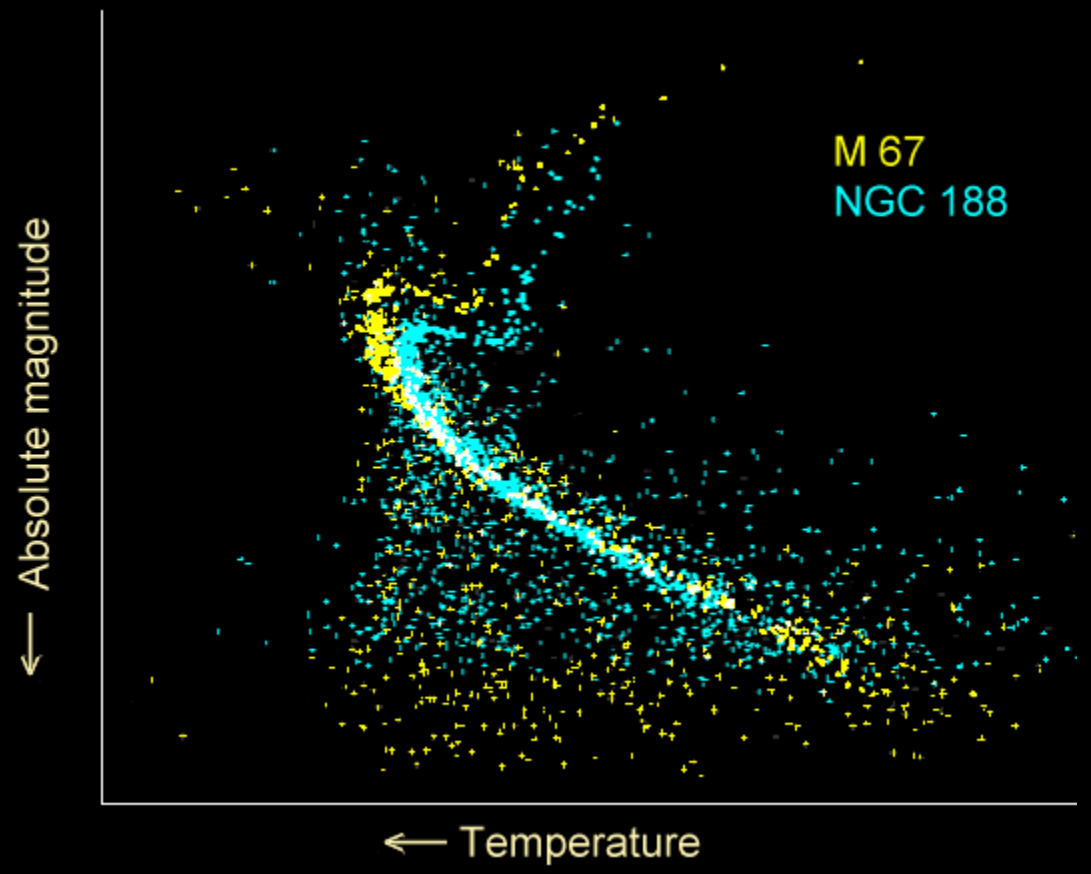
$= 4.725 \times 10^{-5}$

$= 4.73 \times 10^{-5}$ km (3 sf) #

Approximate distance to Coma Star Cluster

FYI: You're saying its 4.73 cm away from you

Missing the Forest for the Tables



700M years

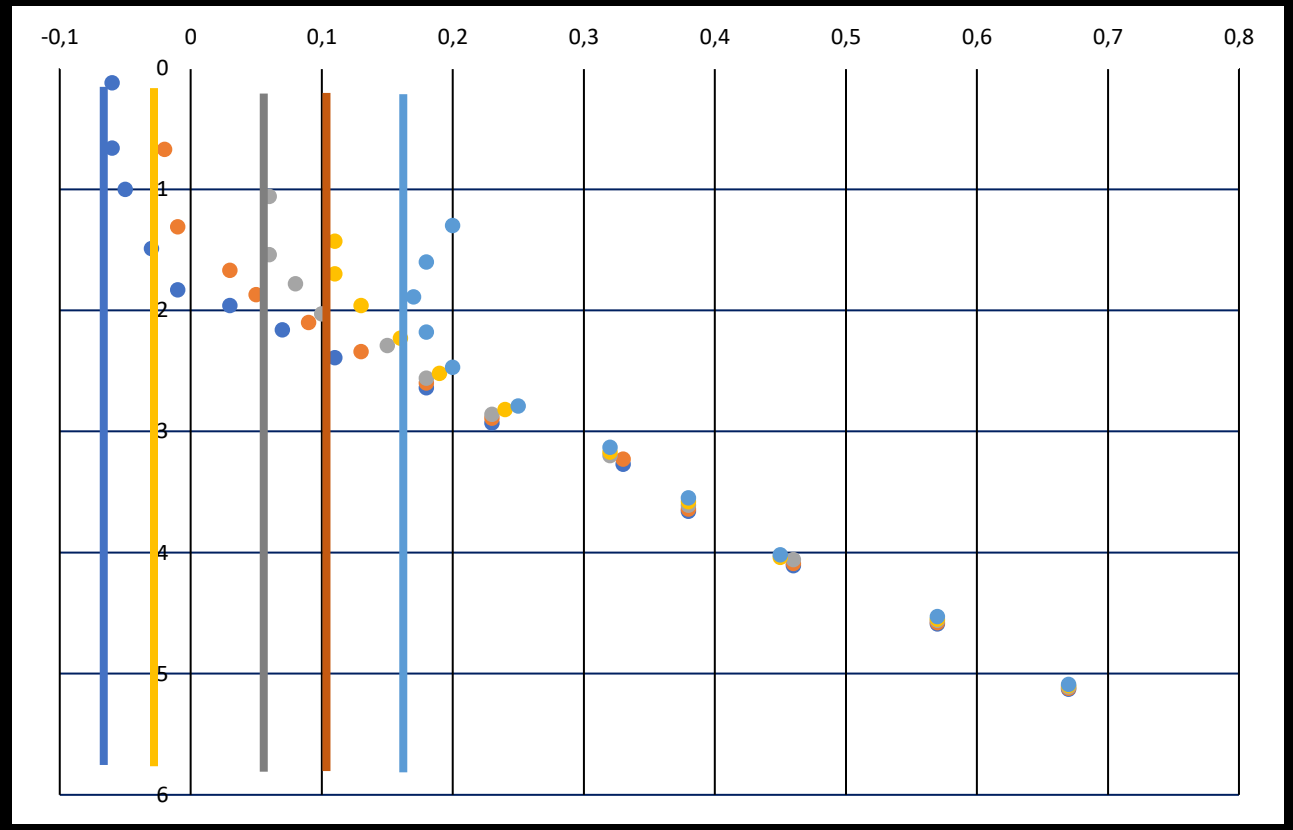
Mass	L	R	Teff	Bol	B-V	Mv	ST
1	8.83E-01	9.07E-01	5738	4.89	0.67	5.1	G6
1.1	1.42E+00	1.03E+00	6058	4.37	0.57	4.55	G0
1.2	2.20E+00	1.16E+00	6375	3.89	0.45	4.04	F6
1.3	3.28E+00	1.29E+00	6696	3.46	0.38	3.58	F4
1.4	4.71E+00	1.38E+00	7092	3.07	0.32	3.17	F1
1.5	6.50E+00	1.44E+00	7543	2.72	0.24	2.82	A9
1.6	8.73E+00	1.52E+00	7907	2.4	0.19	2.52	A7
1.7	1.15E+01	1.64E+00	8185	2.1	0.16	2.23	A7
1.8	1.50E+01	1.78E+00	8396	1.81	0.13	1.96	A5
1.9	1.93E+01	1.97E+00	8484	1.54	0.11	1.7	A4
2	2.47E+01	2.24E+00	8490	1.27	0.11	1.43	A4

Missing the forest for the tables…

Key Insight: Clusters become **redder** as they age

- the bluest and most massive stars run out of fuel first.

- Simply scan each table for the bluest B-V value, compare against the turnoff point.

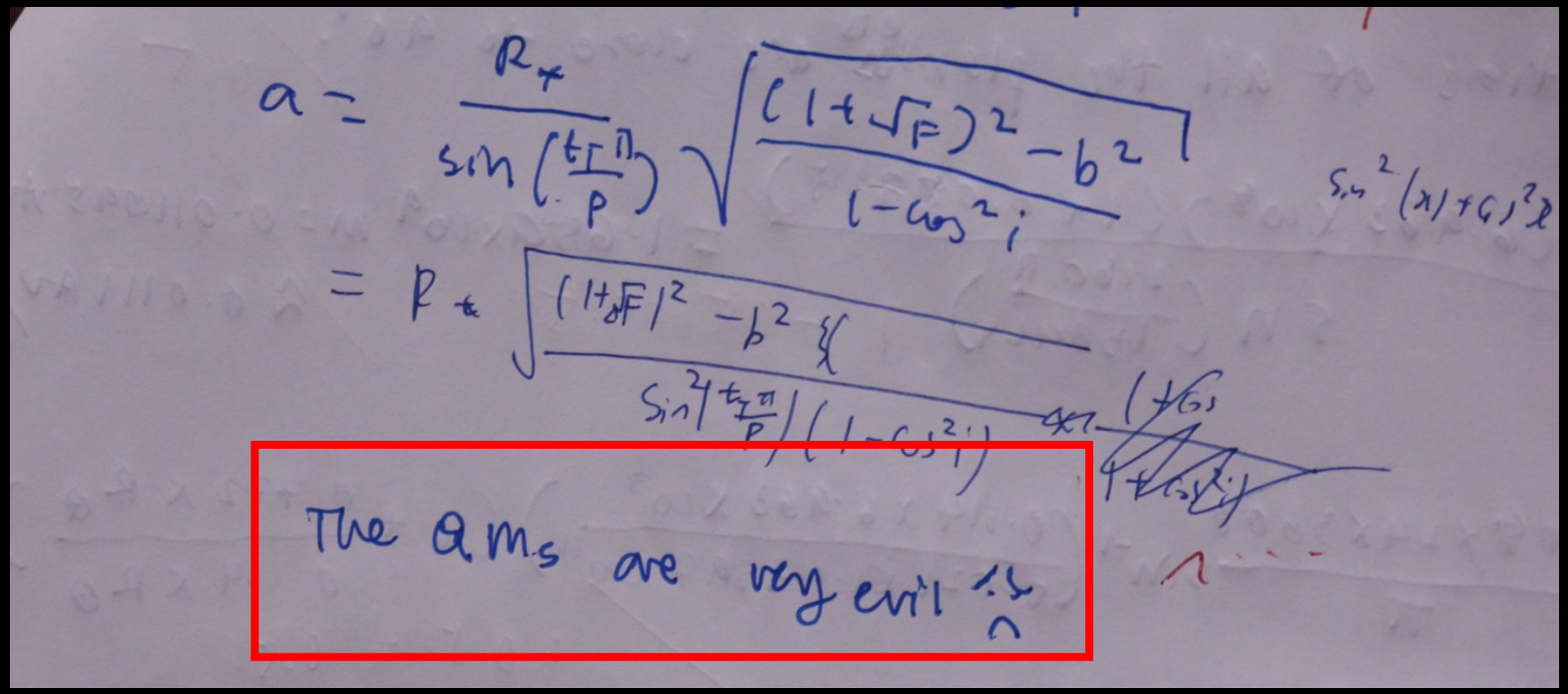


Key takeaways from Q3/Q4

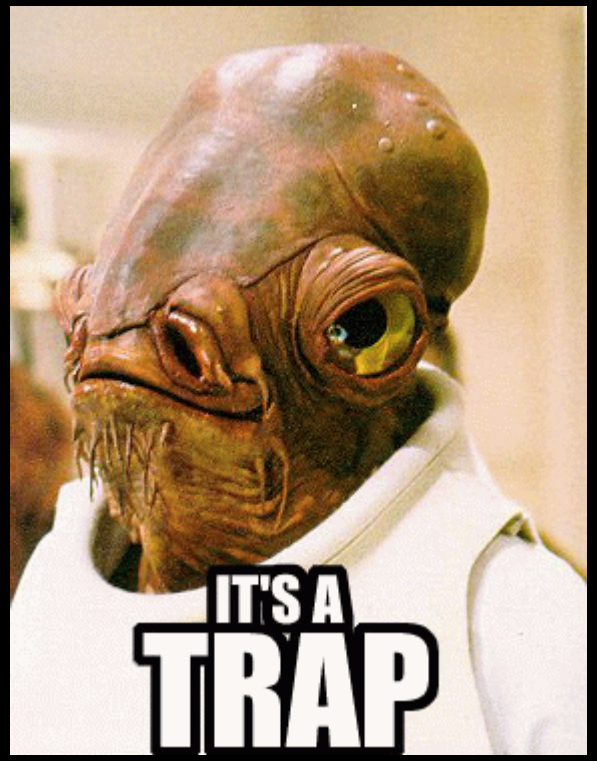
Please understand your math!

Math is **NOT a means of hiding your ignorance**

If you're completely lost, talk to the QMs!



Q4: IT’S A TRAP(PIST-1)



What happened?!

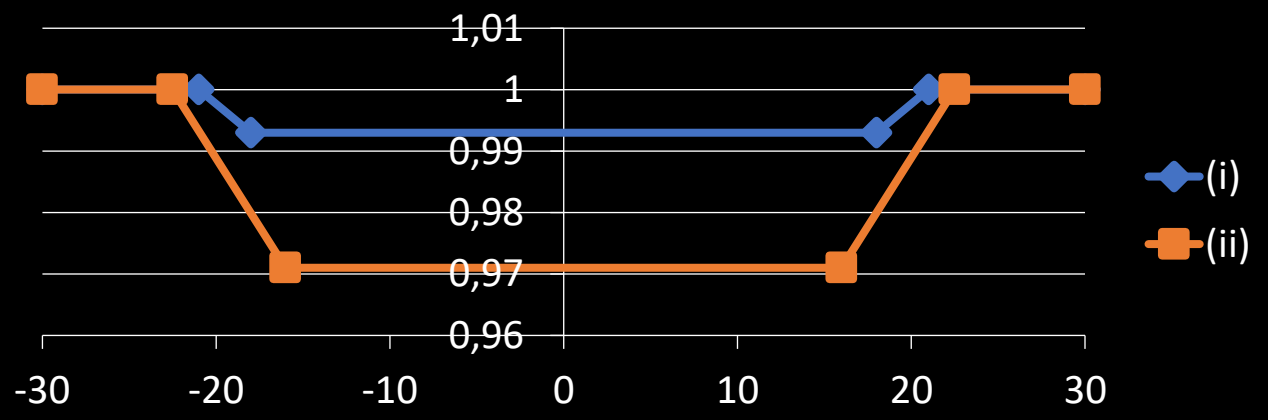
Recipe for a disastrous but easy question:

1. Find a scientific paper about a simple concept but explores it in great depth.
2. Make sure the first 3 marks is as tedious as possible.
3. The next 10 marks is actually doable.
4. The next 5 marks is a theory section for those who can’t maths.
5. The last 4 marks is seemingly difficult but doable with wisdom.

What was expected:

1. Spend time digesting the information and appreciating the formulas.
2. If you're good, work out the first 3 marks. Else, skip it and move on!
3. The middle 10 marks is typical for AC.
4. Grab an easy 5 marks for those who studied for AC.
5. Sketch a curve for 4 marks.

(This didn't happen)



Surefire way to be featured in the Post Mortem

1. Stating the obvious:

What is the **key assumption** made, in order to obtain equation 7 from equation 4 in the process?

- Assumed that system observes Kepler's third law.
- Light travels at 3*10^8 m/s.

2. Fail to press panic button AGAIN.

[DON'T PANIC]*

Surefire way to be featured in the Post Mortem

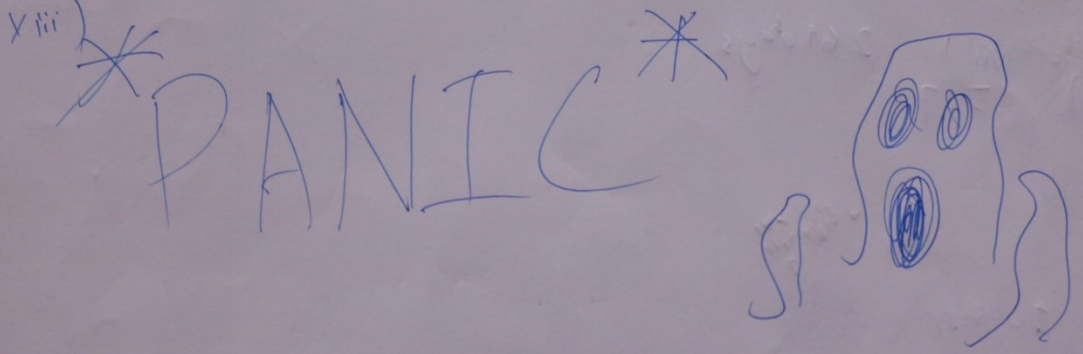
3. Not practicing exam wisdom:

- Spending ~~forever~~ 1 hour doing Q4 part i), despite it being unnecessary for the rest of the paper
- Not counting marks and skipping questions entirely (most ironically, the question above the DON'T PANIC button…)
- (THESE ARE IMPORTANT FOR YOUR PROMOS, O/A LEVELS!)

4. Failing to divide and conquer, e.g. passing the theory section to your group's theory expert

slightly since both objects orbit a common center. Hence, from Earth's perspective, the star will change it's radial velocity ~~periodd~~ periodically as it moves further and closer. This can be measured as a periodic change in the spectrum of light due to ~~changing~~ ~~drifting~~ ~~do~~ doppler effect.

xiii)

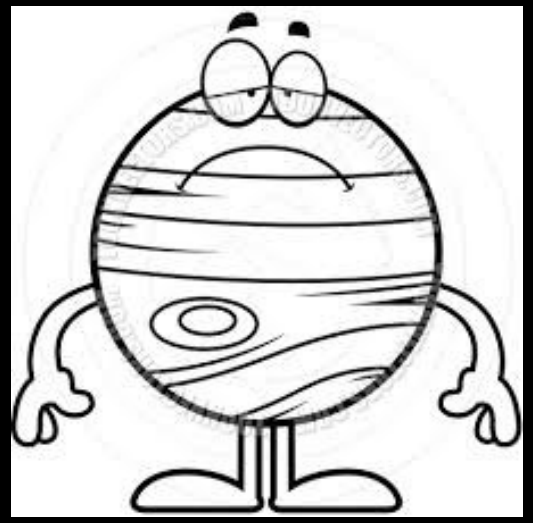


Surefire way to be featured in the Post Mortem

5. Giving up

- Calculate the transit duration of TRAPPIST-1d, leaving your answer in number of **days.** Ans: 269 days, with no working.
- Determine which planet is featured by the above light curve, showing clear evidence why you think so. Ans: Jupiter.

Can I move to TRAPPIST-1a?



Surefire way to be featured in the Post Mortem

6. Not knowing your basics

- List of things people do not know: Semi-major axis, **Habitable Zone**, Tidal Locking, Tidal Heating, Orbital resonance…

- Habitable zone
- … ensures optimal temperature **and gravity** for water
- … necessary **for farming** and sustaining life (Sigh…)
- … will **definitely** have life

Farming points from the Habitable Zone

華僑中學

HWA CHONG INSTITUTION

NAME

SUBJECT

MARKS

INDEX NO.

CLASS

DATE

x) The habitable zone indicates the region where planets orbit in contain liquid water necessary for forming and sustaining life, so the search for extraterrestrial life can be narrowed down to these regions. Based on the average orbital radii of all the planets in Trappist-1 star system, it shows a high probability of finding lifes there.

Chinese Communist Farming in the HZ

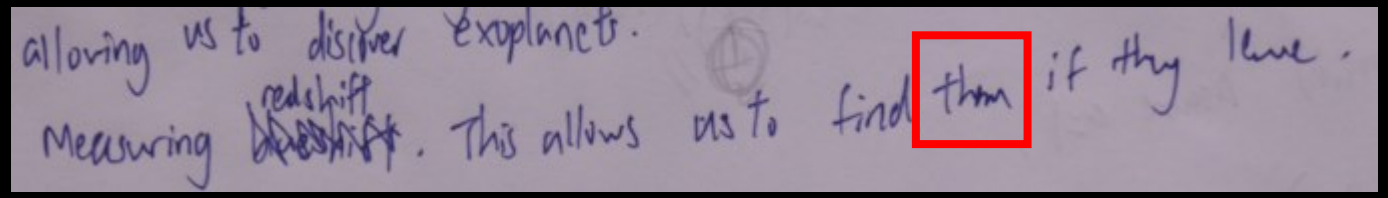
Surefire way to be featured in the Post Mortem

7. Egregious smoking

Tidal heating:

- Orbital resonance also allow **regular high and low tides to catalyse polymerase chain reactions**

Suggest two other methods other than the transit method for discovering exoplanets, and **briefly** state their principles:


alloving us to discover exoplanets.
Measuring redshift. This allows us to find them if they leave.

Surefire way to be featured in the Post Mortem

Thankfully, I defused one on the spot >.>

Ans: Telescope, Redshift. (You are awarded half a mark for two words!)

Answer next time: Direct Imaging, Doppler Spectroscopy (This would be one mark, and one more for stating their principles.). Don’t write silly sentences for the sake of ‘padding’ up your question!

Key takeaways:

1. Be Exam smart.

- Don’t attempt monstrous sections unless you have extra time (Do question 4 (i) LAST.)
- If your answer does not make sense, look for your error (e.g. missing term or wrong calculator mode)

2. Write with a purpose in mind, to answer questions.
3. Hone your basics.
4. Recognise the paper tiger (or alien): Scary from far, far from scary.

Q5: Elliptical Orbits

Summary and Expectations

- Recall basic definitions (i and iv)
- Apply the principles of conservation of angular momentum and conservation of energy (ii, iii and v)
- Application of Kepler's second law (vi)
- Simple calculations using the given equation in the question and formula booklet for v_{ape} and v_{pe} using the equation provided (vii) and angular momentum (viii)
- Vector addition of linear momentum or angular momentum (ix)

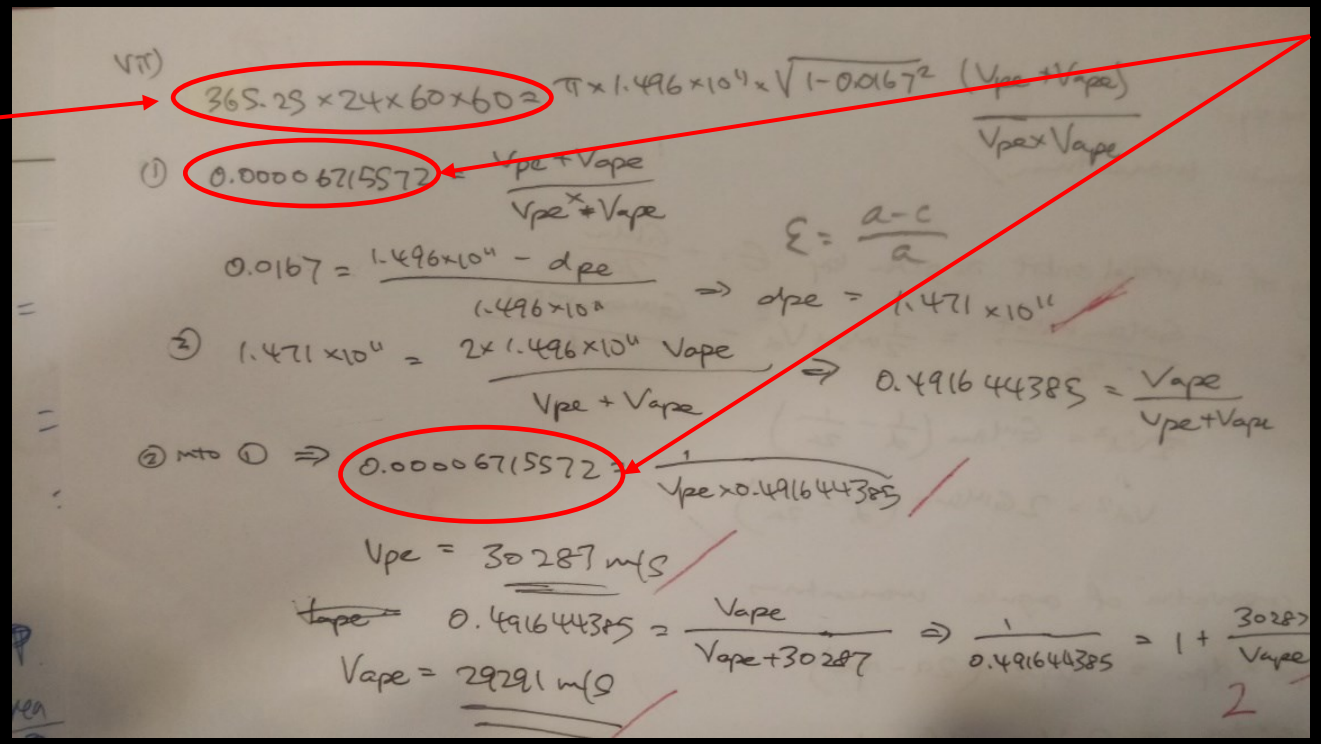
Common errors

- Students are too used to circular orbits (perhaps from A level physics) and used the wrong formulae, for instance:
  - KE = GMm/2r
- L = mvr (factor of sin Θ ?). In an elliptical orbit, r may not be perpendicular to v.
- Imprecise statement of Kepler's second law: common phrasing goes like "The planet sweeps out…"

Major Error: POOR PRESENTATION!

- Not stating the physics principle used
  - Principle of conservation of energy and angular momentum
- Not stating the formula used

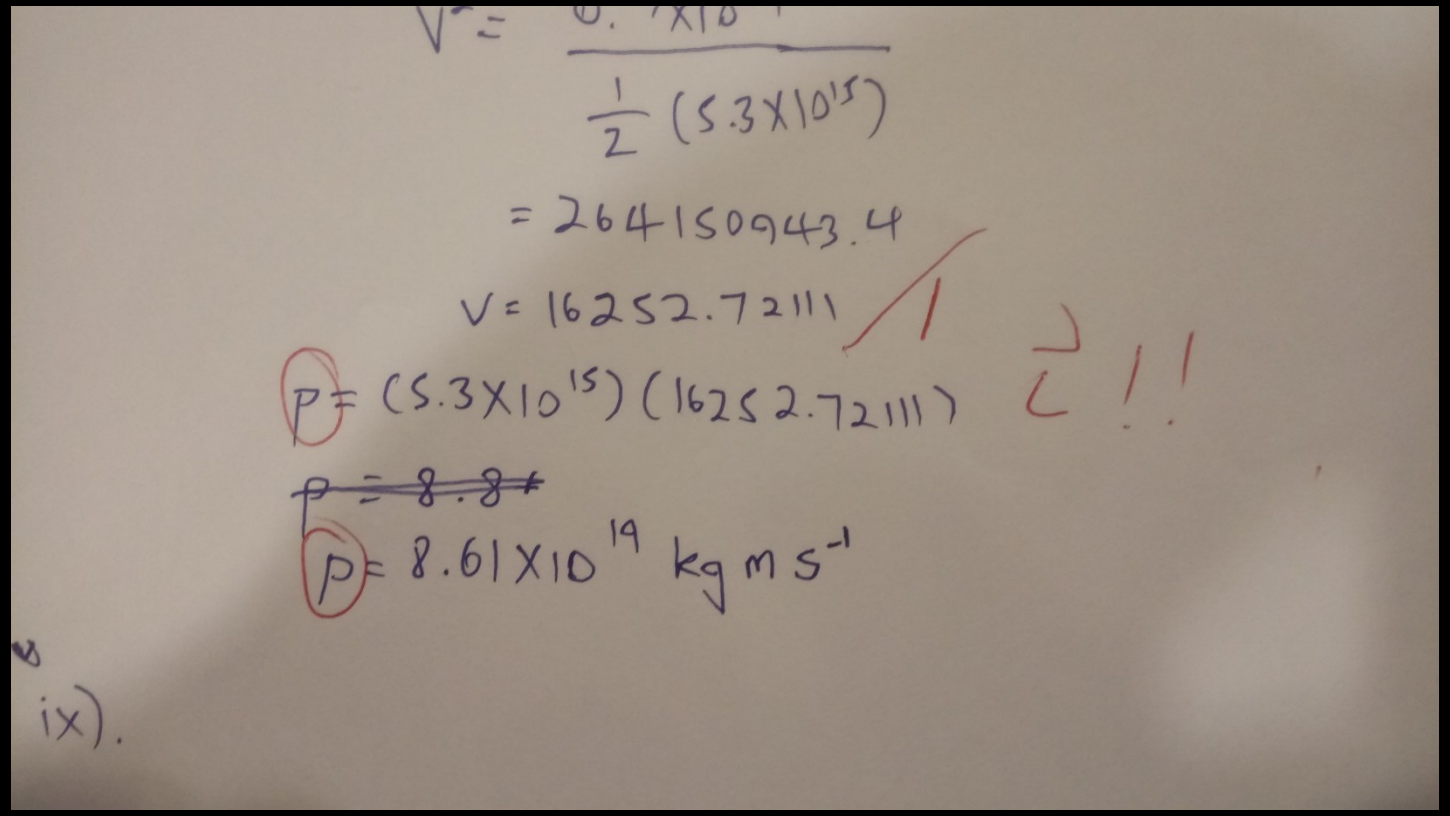
Tell me what this number is!



You may have given me more zero's than I have given

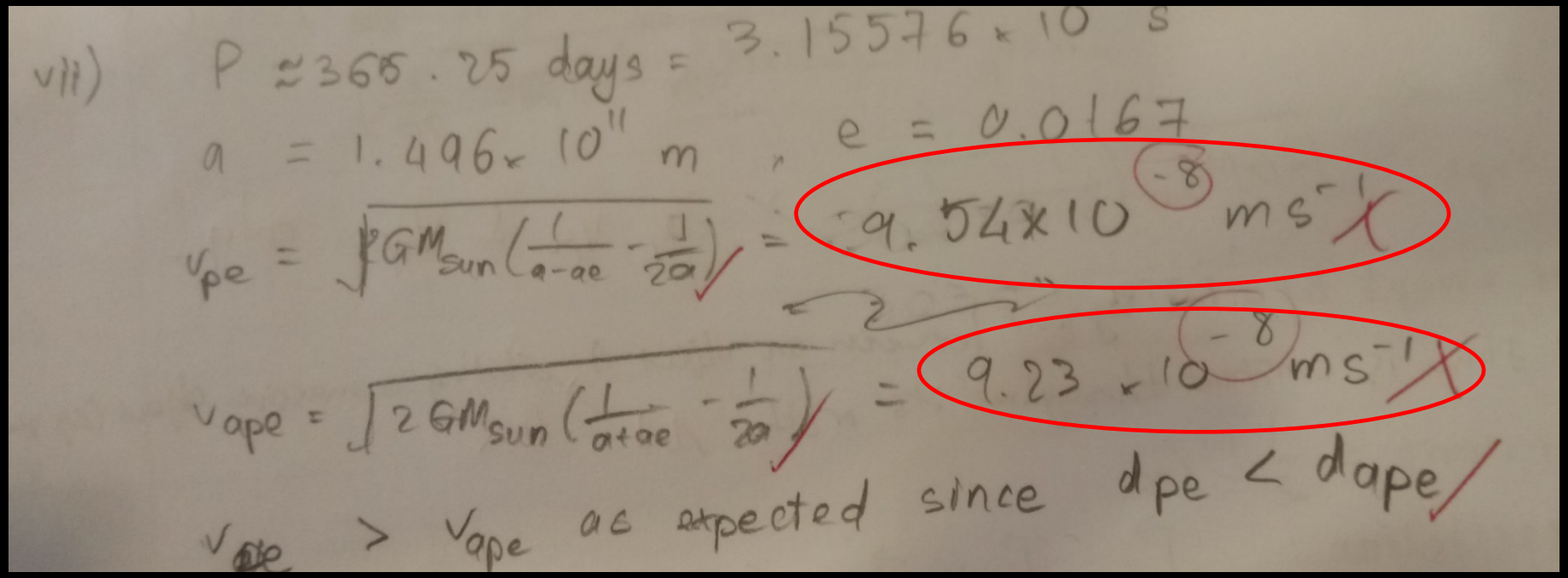
Surefire way to be featured in the Post Mortem

- The question asked for angular momentum and you gave….



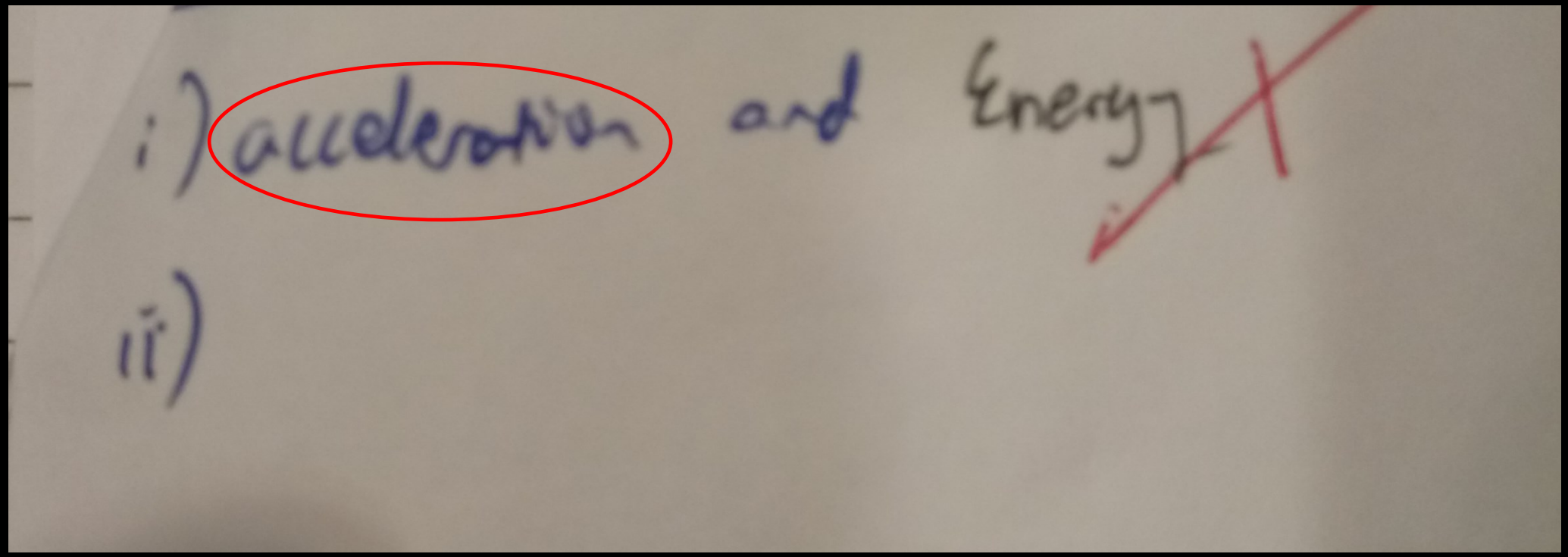
Surefire way to be featured in the Post Mortem

- Not checking if your answer makes sense….



Surefire way to be featured in the Post Mortem

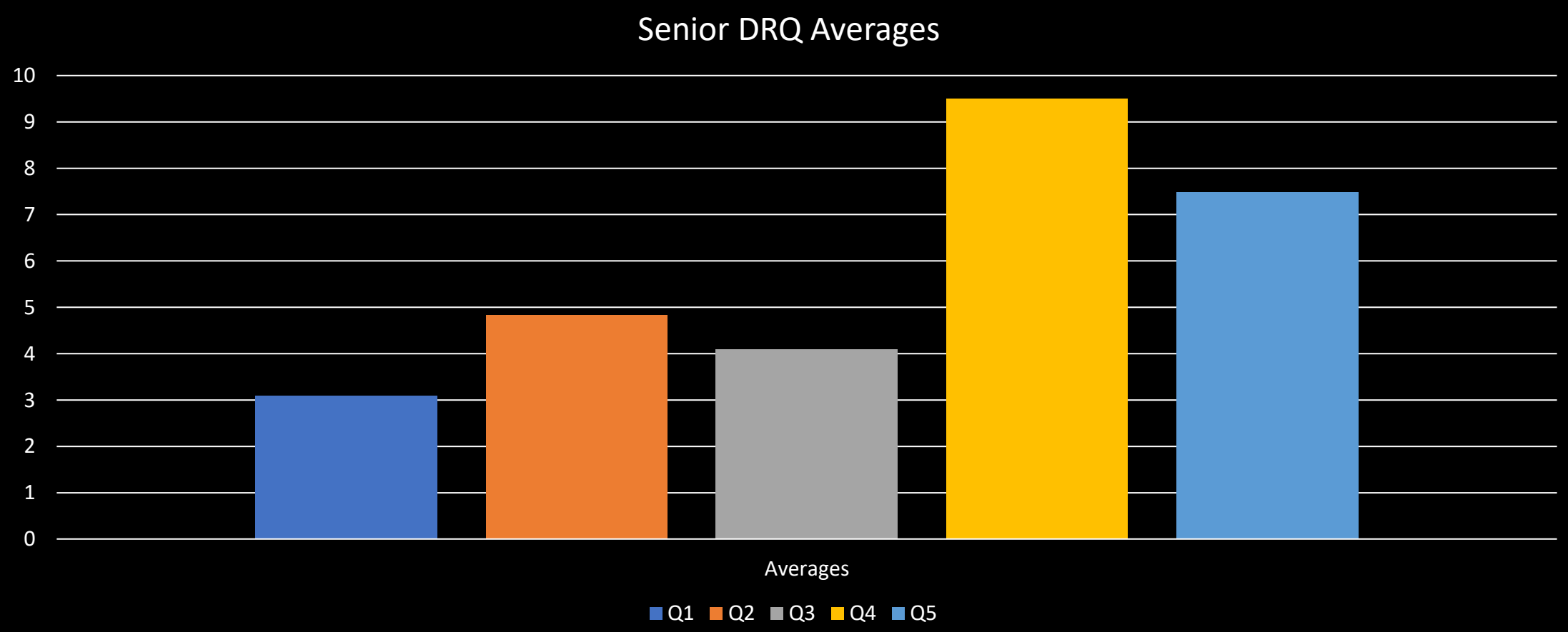
- As a physics major, I learnt a new principle today: conservation of acceleration



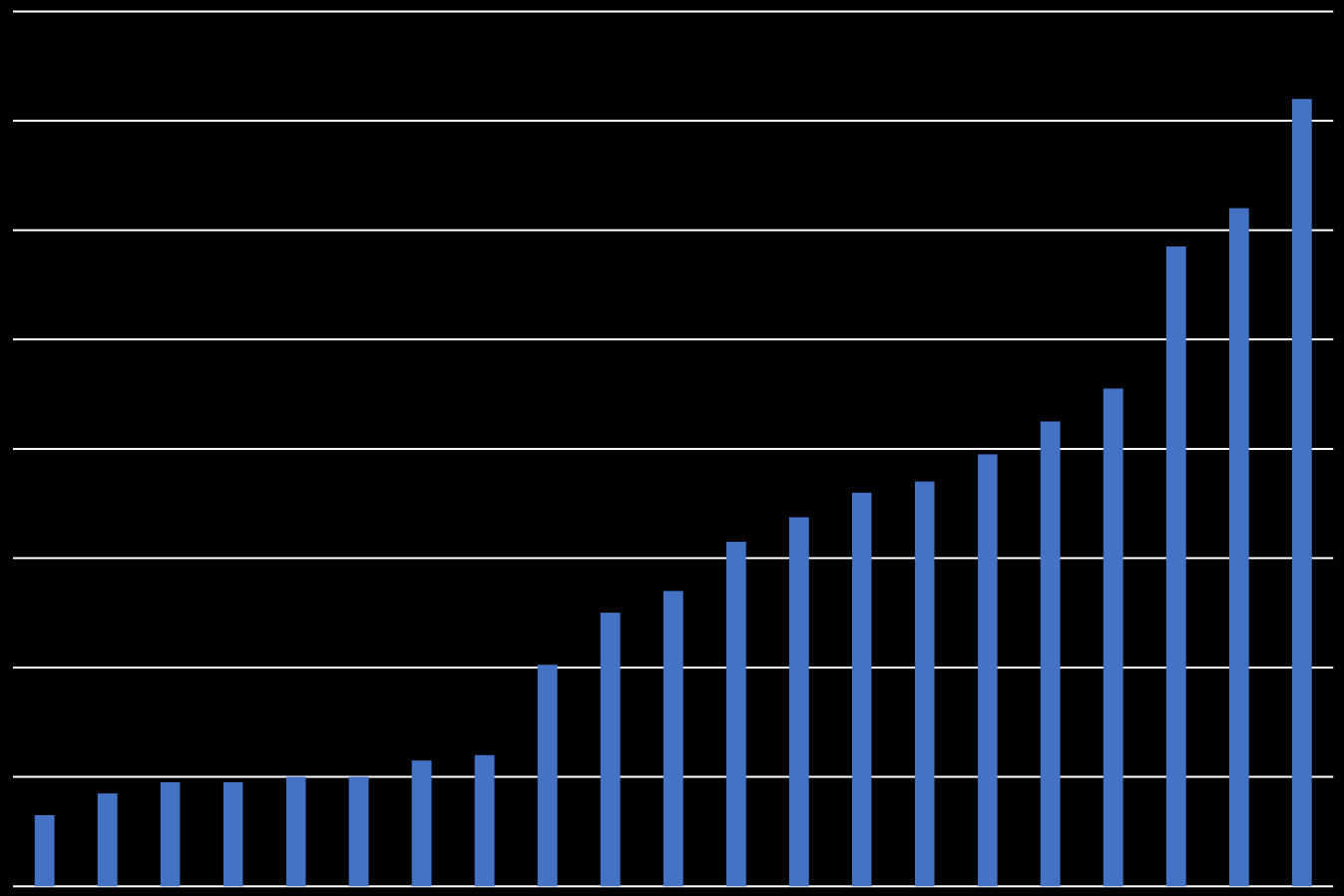
Key takeaways

- As this question is mainly on computation, always refer to the formula booklet for what you need
- Remember your definitions more precisely
- Always do a sanity check: make sure your answer makes sense!
- Please write your workings with the proper presentation: give the marker a less severe headache (one team did this very well for this question; I enjoyed marking the question)
- This question requires only a few basic physics principles: master them well and the question is trivial

Senior DRQ Average Score by Question



SNR DRQ Scores (Mean = 28.95, SD = 19.5)



JNR DRQ

Cave in a Tundra

Junior DRQ Question 1

(Set by the guy with a particle accelerator)

Cave in a Tundra

Black Holes

are Really Cold

Goal of the Question

- Black hole thermodynamics: Hawking radiation can be modelled closely to a perfect blackbody, giving black holes a “temperature”.

- We can see that using simple algebraic equations, we can model how black holes evolve over time.

Expectations

- Primarily a question on radiative thermodynamics
- Equation Substitution
- Qualitative questions to test understanding of the purpose of all the calculations, and understanding of the important result that total emissive power of a black hole is inversely proportional to R^2

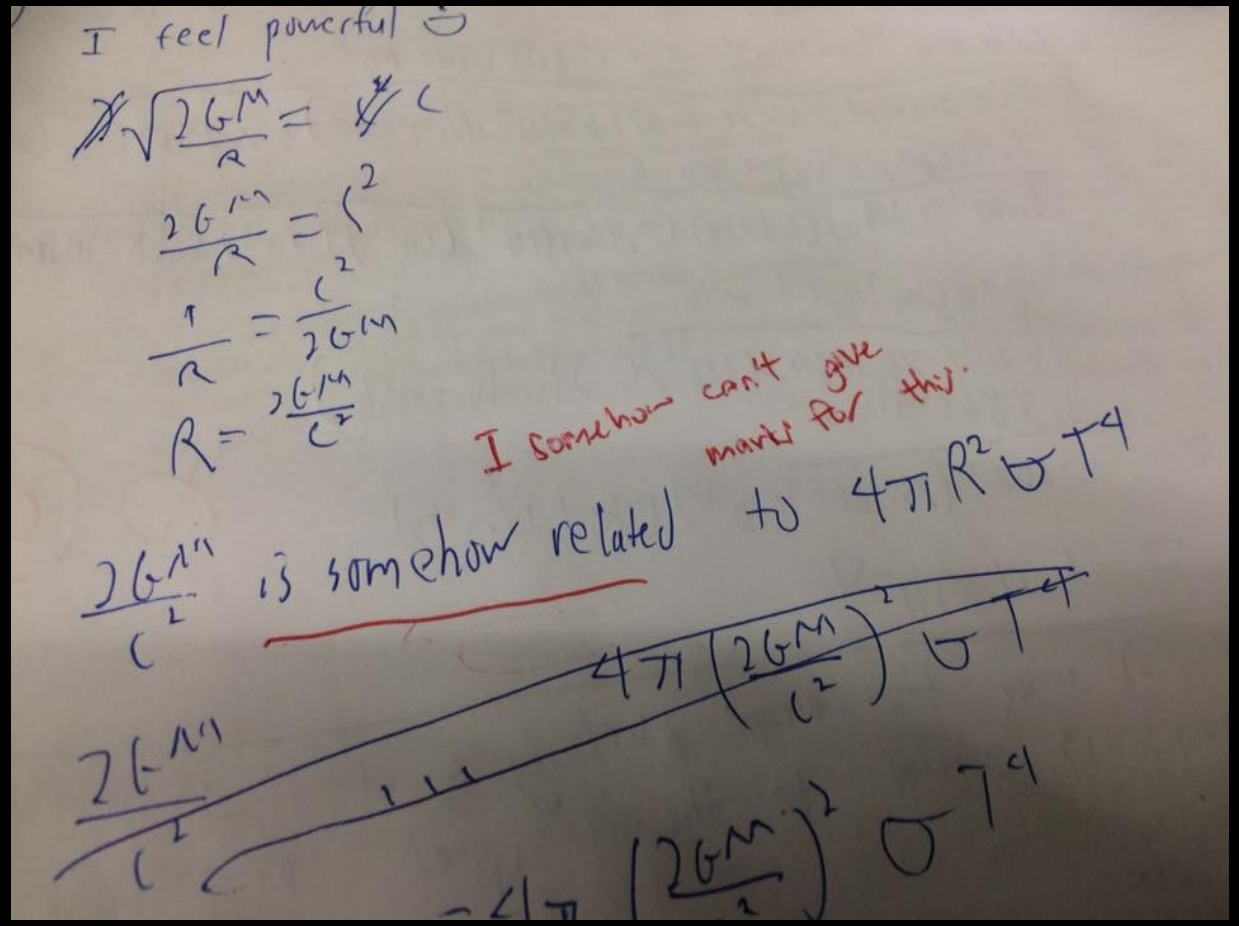
Major Common Mistakes

- Treating the radiation from the sun that is absorbed by the black hole as being isotropic (taking $4\pi R_{\text{photon sphere}}^2$) instead of being from a point source at infinity ($\pi R_{\text{photon sphere}}^2$)

- Substitution/math errors which prevent the important result of [$P_{\text{Hawking Radiation}} \propto R^2$] from being found, affecting some questions downstream

- Where possible, I mark with error carried forward

Major Common Mistakes



Major Common Mistakes

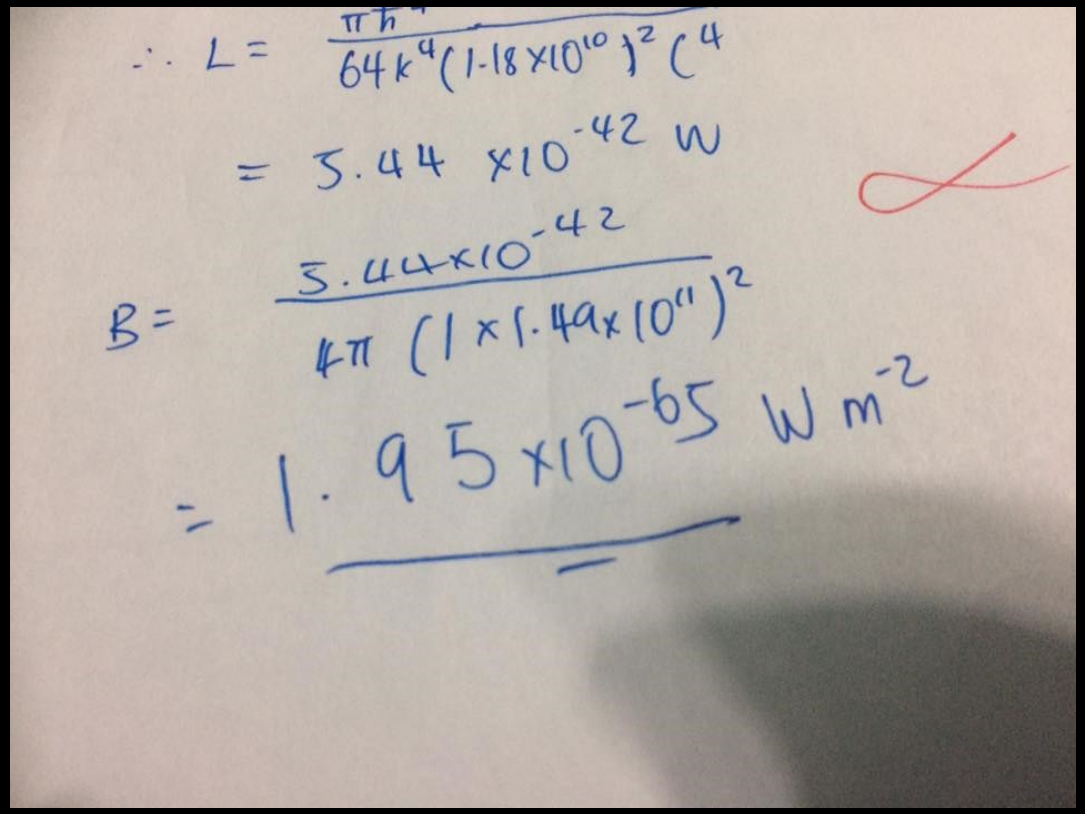
- With that said, it is always <u>GOOD PRACTICE</u> to write something with at least a germ of logic

Other Notable Errors

- I think I need to work harder at dropping hints T-T

v) Find the solar radiative flux at a distance of 1AU [1 mark]

Given that at 1 AU, there is a solar radiative flux of 1.4 kW/m^2.



Earth in another Turf

Junior DRQ Question 4

(Also set by the guy with a particle accelerator)

Goal of the Question

- Part I: Looking at a possible, albeit highly unstable orbit around a Binary Star System

- Part II: Tidal Locking and its implications on how we think of habitability

Expectations

- Math is not difficult per se, but equations can be quite long, making careless mistakes quite likely.
- Understanding of the question’s purpose is essential (especially for Part II)

Where Everyone Died

- Part I is generally alright
- Nobody got the final answer for part II. For those who made it this far, the question that pretty much killed the remaining survivors is…

Where Everyone Died

The inner and outer radii of the habitable zone of a star can be approximated by the following equations:

$$r_{inner} = (L_{star}/1.1L_{sun})^{0.5}$$
$$r_{outer} = (L_{star}/0.53L_{sun})^{0.5}$$

Where r is measured in Astronomical Units

vii) Using the above information, provide an expression for a (in appropriate units), the semi-major axis of the planet for our calculations, in terms of L_{star} and L_{sun} [1 mark]. Briefly explain your answer in qualitative terms [1 mark].

Where Everyone Died

Assuming an Earth-like planet in a circular orbit, we will calculate the smallest mass of star in which the planet can orbit in the habitable zone without becoming tidally locked within 1 billion years.

- This was kind of a troll question to test your understanding of the purpose of the question.
- Almost everyone took it as an elliptical orbit.

Where Everyone Died

The inner and outer radii of the habitable zone of a star can be approximated by the following equations:

$$r_{inner} = (L_{star}/1.1L_{sun})^{0.5}$$

$$a = \boxed{r_{outer} = (L_{star}/0.53L_{sun})^{0.5}}$$

Where r is measured in Astronomical Units

vii) Using the above information, provide an expression for a (in appropriate units), the semi-major axis of the planet for our calculations, in terms of L_{star} and L_{sun} [1 mark]. Briefly explain your answer in qualitative terms [1 mark].

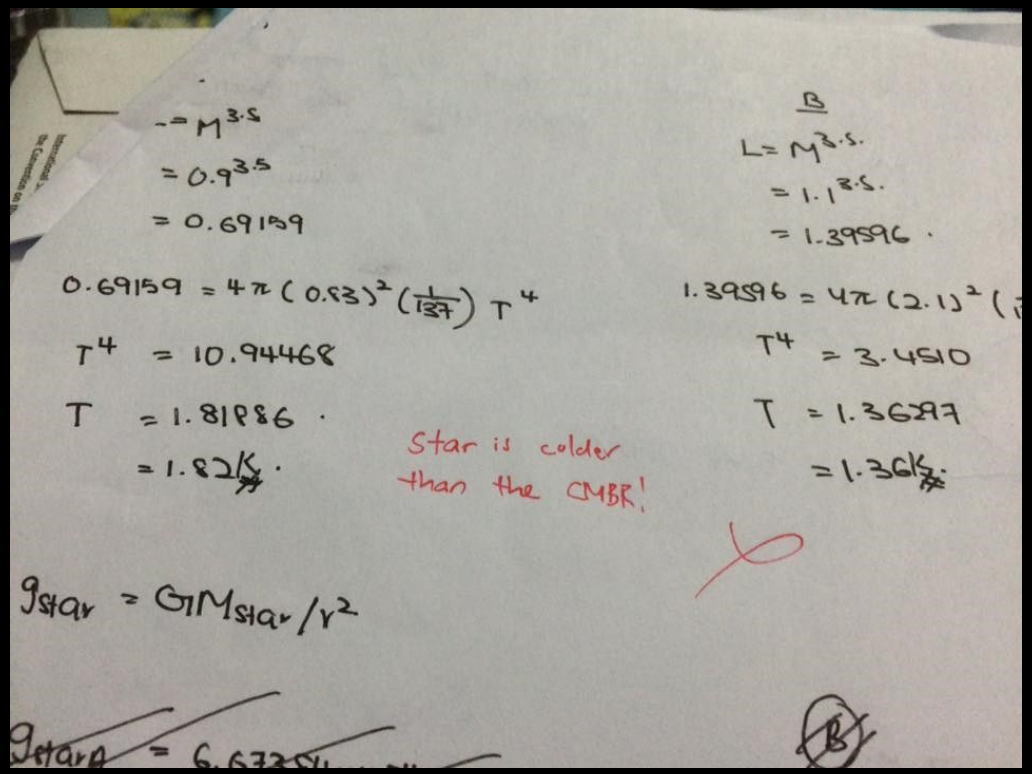
- We take the r_{outer} because it is the point with the LEAST tidal locking whilst still being in the habitable zone.

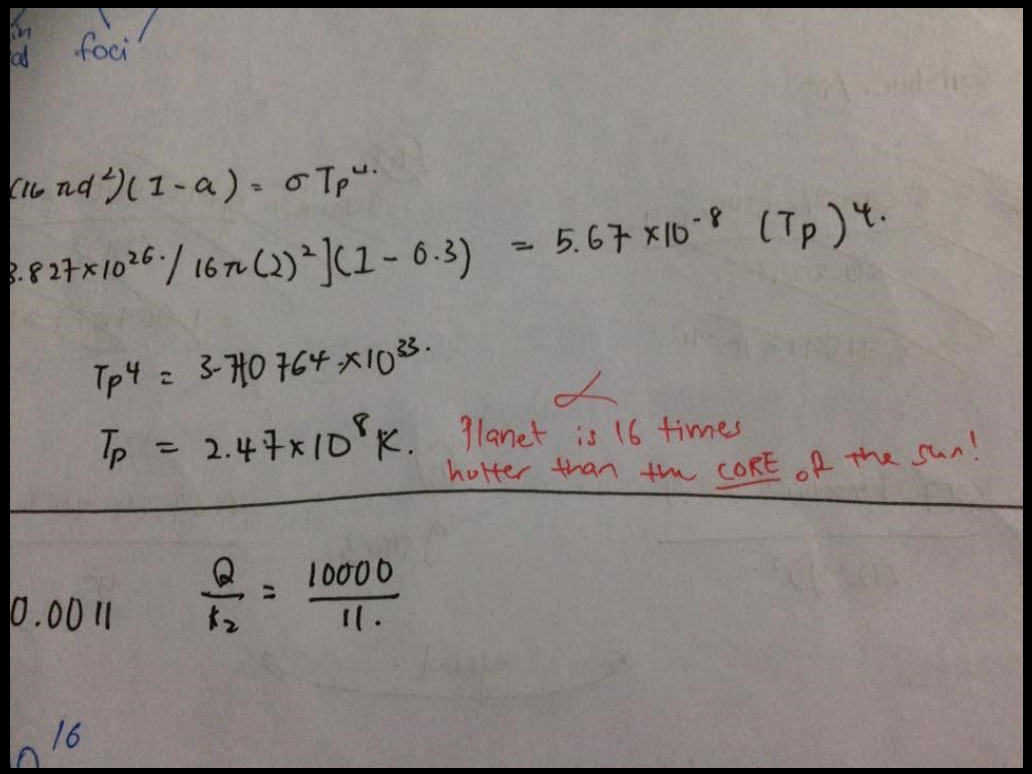
Common Mistakes

- Forgot exponent of reduced Planck's constant, creating a result that is off by 34 orders of magnitude (apparently happened to two teams: quantum entanglement perhaps?)

- Forgot that SI unit for time is <u>seconds</u> and not years (I noted that all units for the equation are in SI)

Some interesting calculations

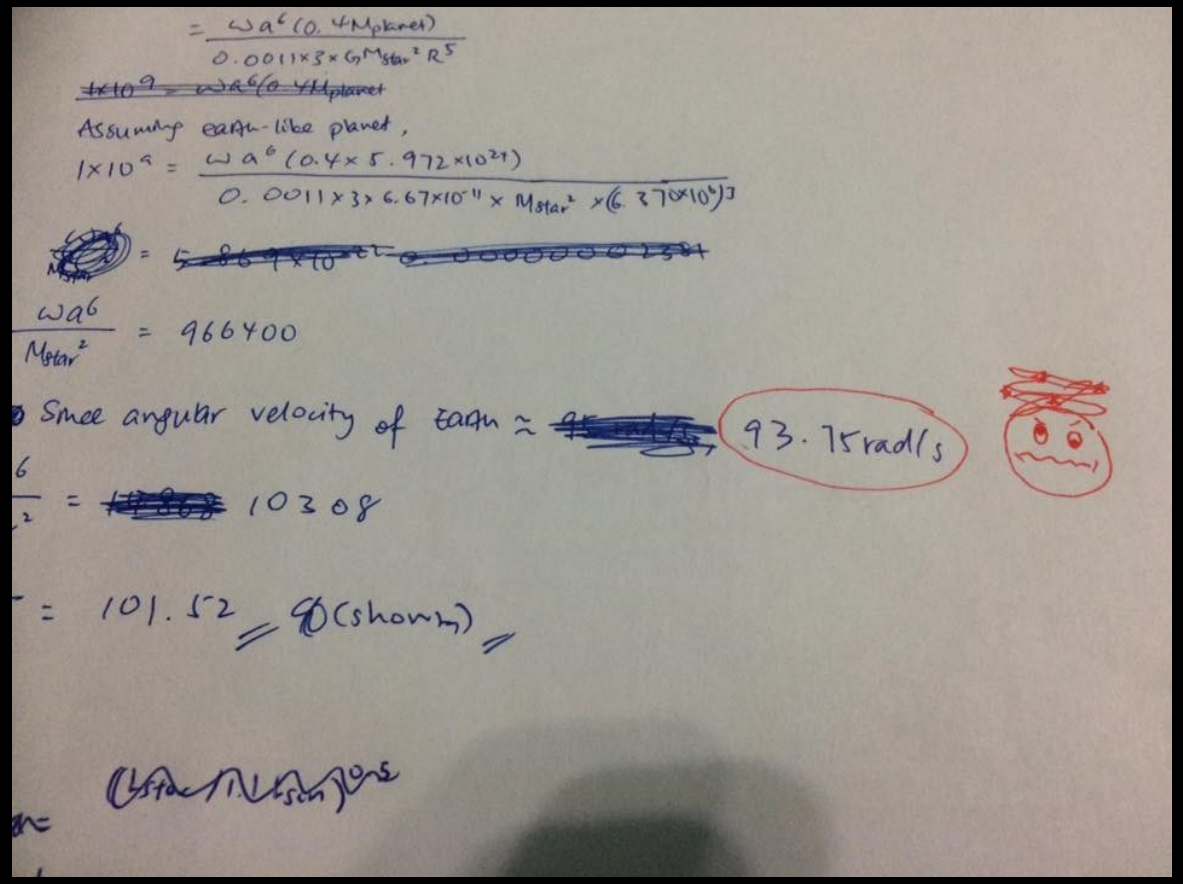




After deducing that the star surface temperatures are even colder than the CMBR…

…It was found that the planet has a surface temperature 16 times hotter than the Sun's core

Some interesting calculations



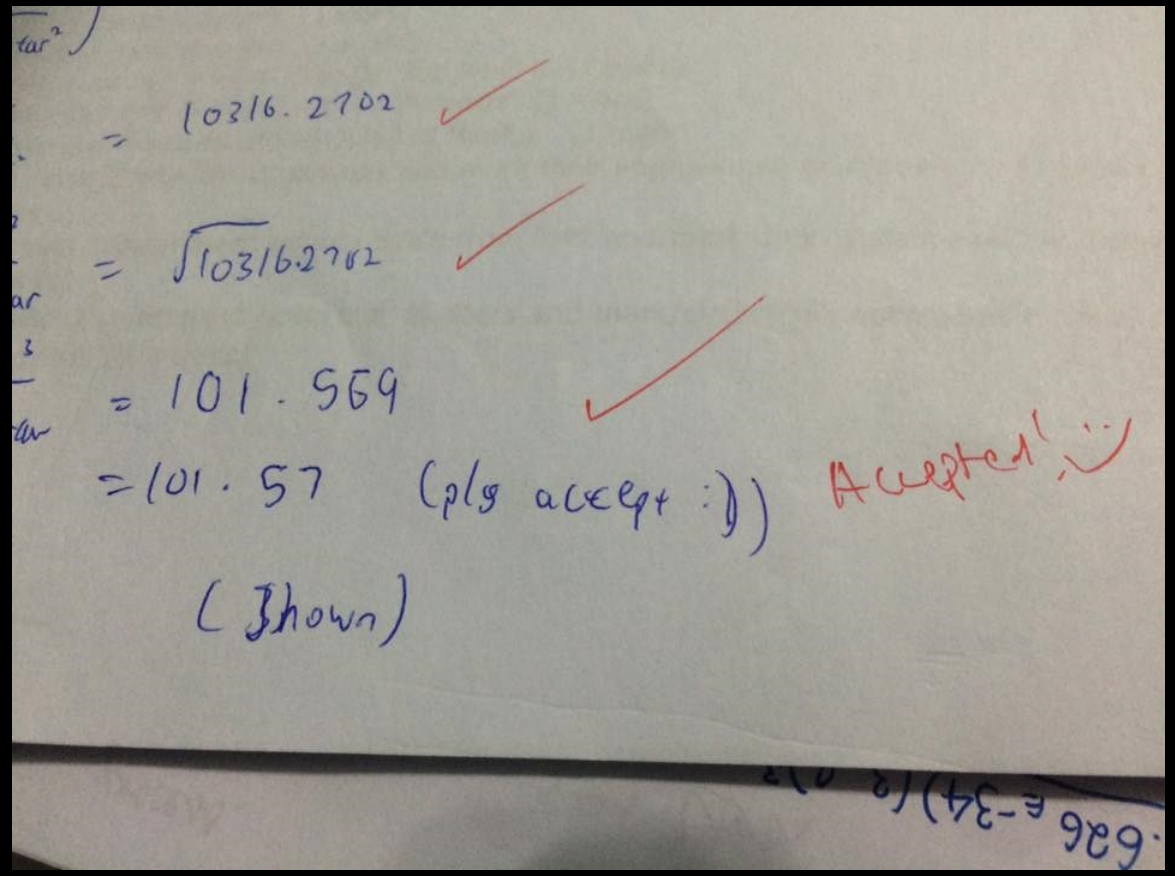
- 93.75 rad/s translates to almost 16 revolutions PER SECOND.
- Conclusion: Earth is a Pulsar!

Some interesting calculations

- My conjecture was that this value was used to “fit” the originally erroneous calculation that used years instead of seconds

- Nice try regardless. I still gave working marks. (no sarcasm here. I like the effort)

On a brighter note…



- Even if the answer wasn't exactly 101.52, I will still give marks! The variations are due to different significant figures used, so I won't penalise for that.

Error in the Equation?

The average surface temperature of a planet orbiting a single star can be estimated to be

$$[I_0/(16\pi d^2)](1-\alpha) = \sigma T_p^4$$

Where I_0 is the star's luminosity constant (3.827×10^{26} J/s for the Sun);
T_p is the average temperature of the planet;
α is the planetary albedo, which has a value of 0.3 for the Earth;
d is the distance from the star;
and σ is the Stefan-Boltzmann constant, which has a value of $5.67 \times 10^{-8} W/(m^2 \cdot K^4)$.

- One team highlighted to me that the constant 16 should have been 4. At first I thought the equation was wrong, so I offered a bonus mark for finding it.
- Upon redoing the derivation, I realised that there is <u>NO ERROR</u>
- Only possible issue with the equation is that I_0 should have been written as L_{star} in accordance with standard notation

Obs Question

Junior DRQ Question 5

(Partly set by the guy with a partic-…well you should have got it by now)

Overview: Part I (Sky Map)

- Most (meaning like half on each of the following) could find the great square, Winter Triangle, Bellatrix and Achernar.
- Many knew Andromeda Galaxy was somewhere in the field of view, but only 1 team correctly identified its position.
- Many knew Horsehead Nebula was in the fov, but none identified its location correctly (the closest to the correct answer identified the star Mintaka, but no marks as you’re on the wrong end of Orion’s belt!)

Overview: Part II (Setting up an EQ mount)

- I did not do negative marking on this question
- This was a new thing for the obs question, so I think it caught many off-guard.

Overview: Part II (Setting up an EQ mount)

- Most managed to identify the following correctly: (1) Mount should point North instead of South, (2) When balancing RA axis, DEC should be locked and RA left unlocked. (3) balancing should be done with all accessories mounted.

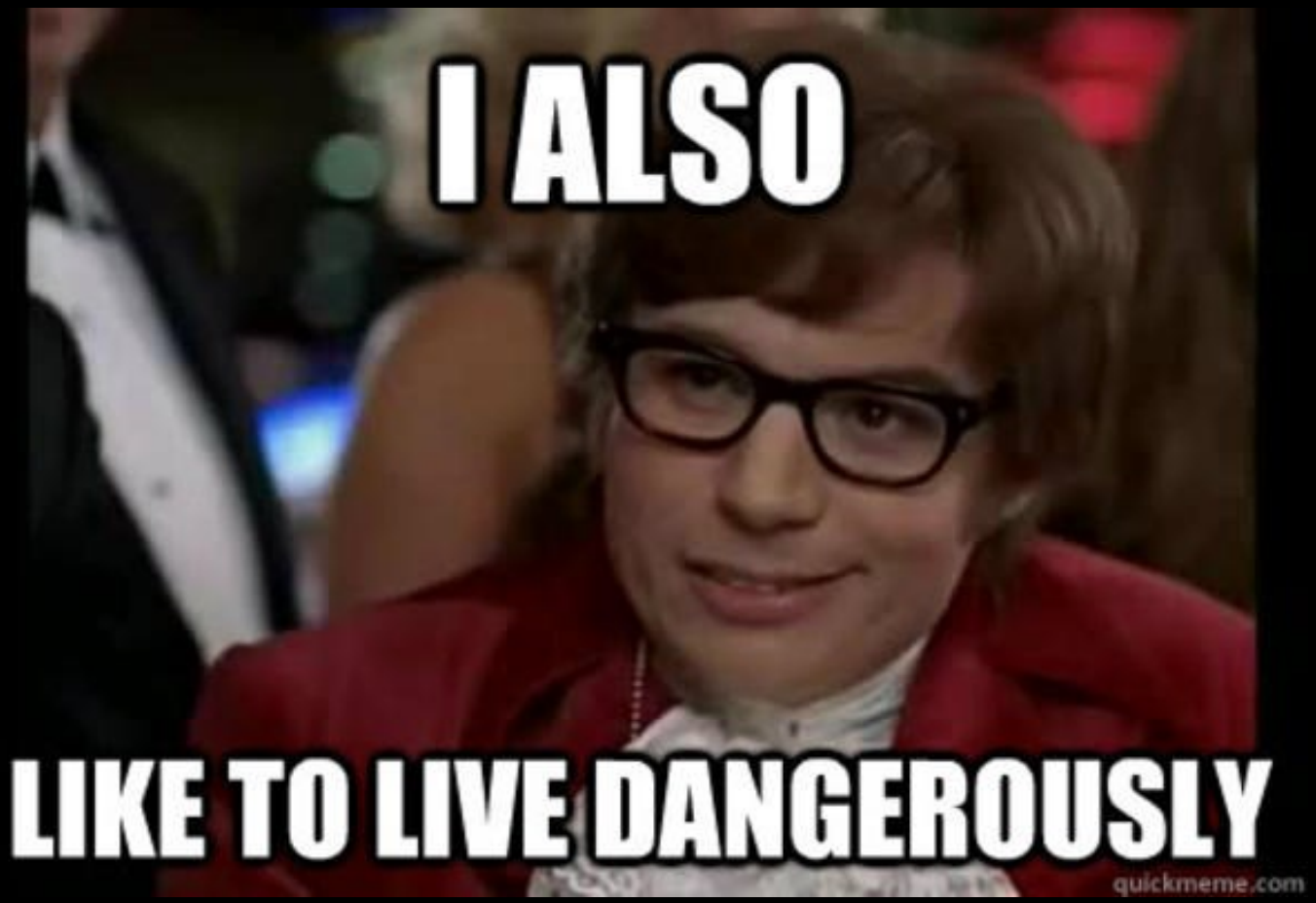
- A few teams noted that North/South didn’t matter, but in the earlier part of the question I stated that the mount is to be set up in SINGAPORE.

Part II common mistakes

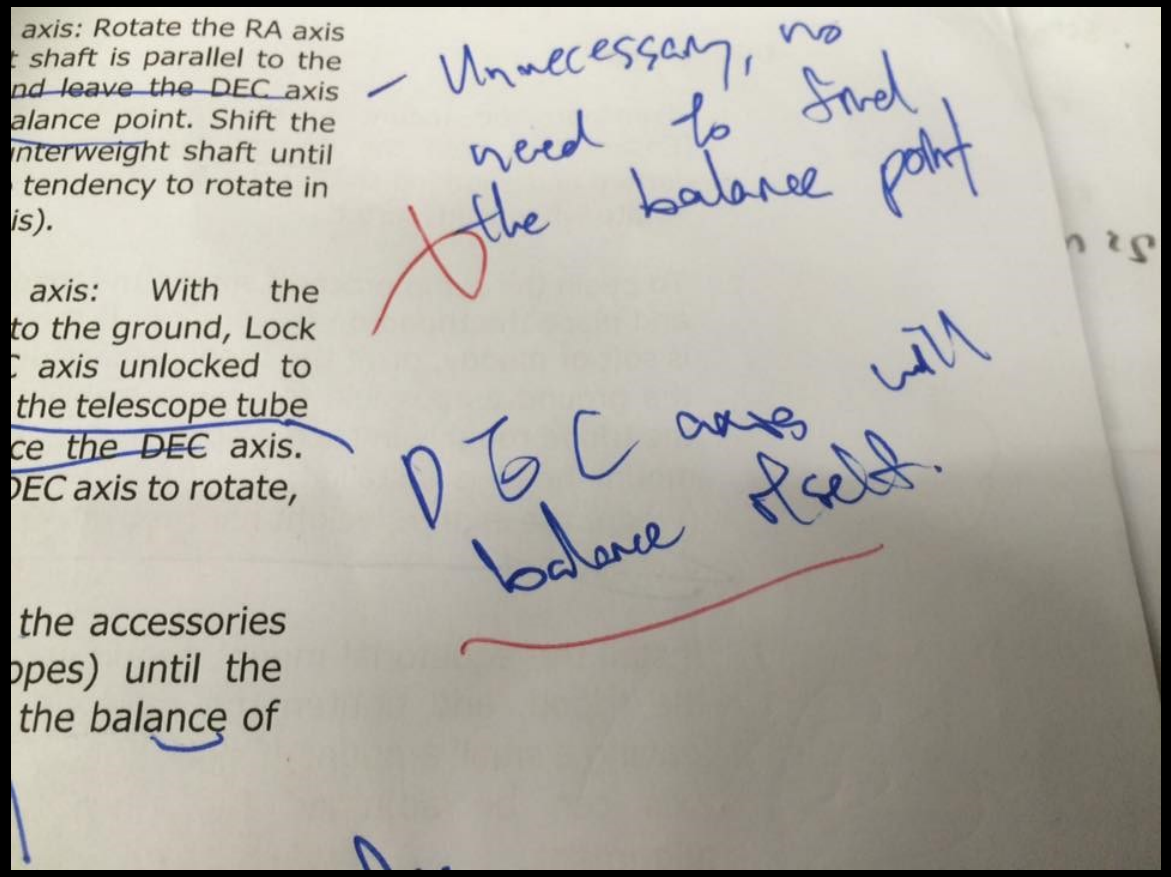
- Many thought that driving the telescope tripod into the ground is wrong, but it is common practice if setting up on grass to ensure that the telescope tripod does not shift later on.

- Most couldn’t identify that I mounted the telescope BEFORE mounting the counterweights. If you tried to do that in real life, all I can say is…

Part II common mistakes



Some interesting answers…


axis: Rotate the RA axis
t shaft is parallel to the
nd leave the DEC axis
alance point. Shift the
nterweight shaft until
tendency to rotate in
is).

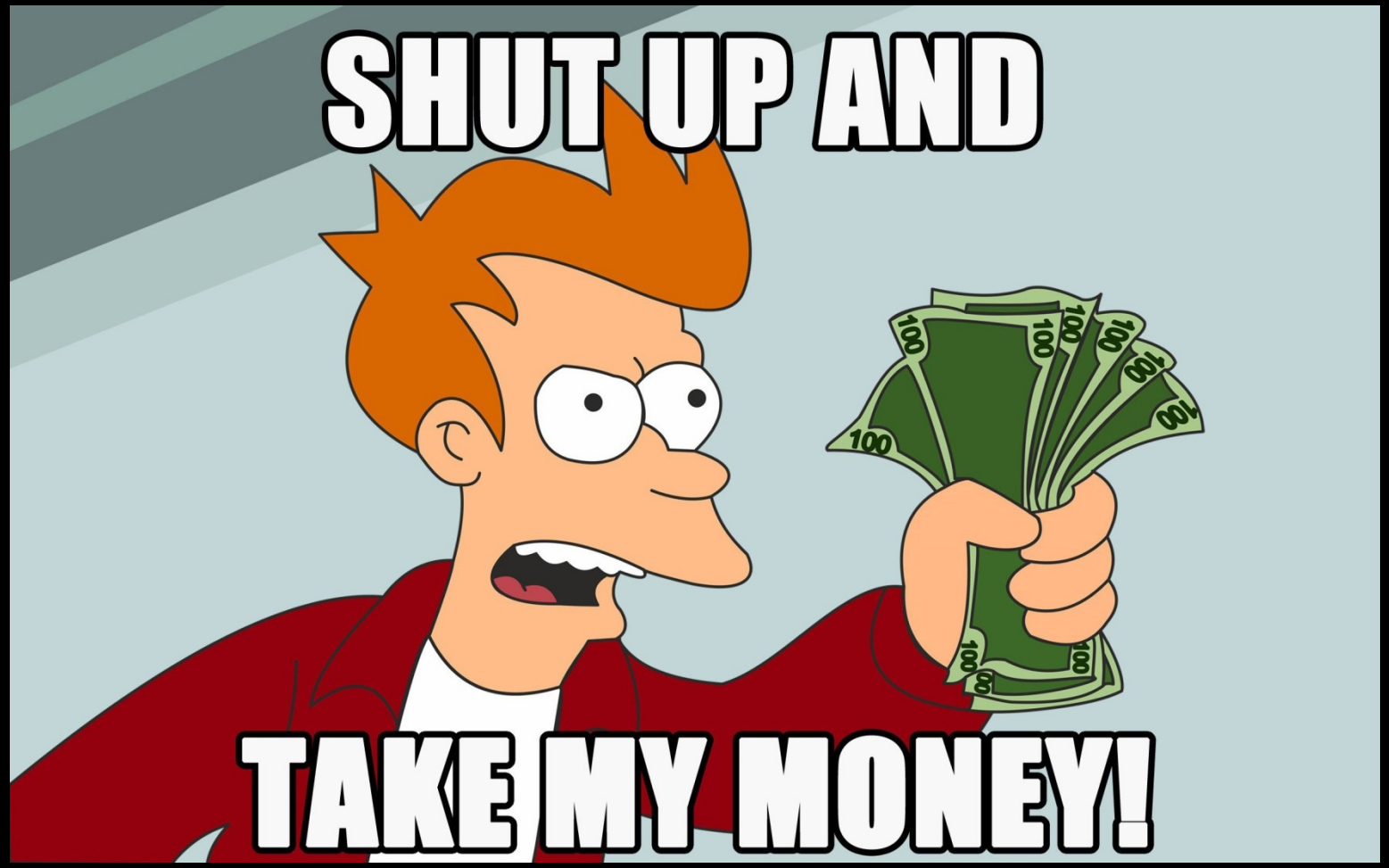
axis: With the
to the ground, Lock
axis unlocked to
the telescope tube
ce the DEC axis.
DEC axis to rotate,

the accessories
opes) until the
the balance of

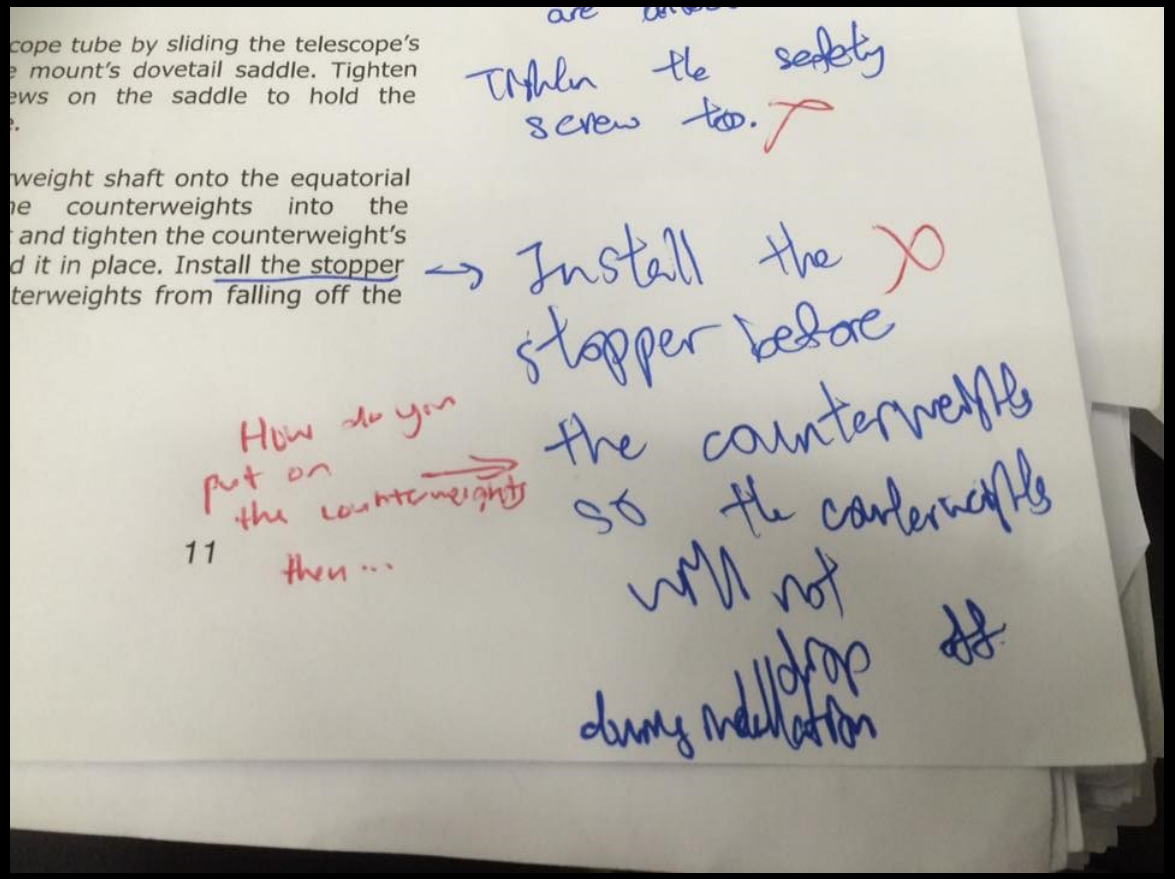
– Unnecessary, no need to find the balance point

DEC axes will balance itself.

Some interesting answers…

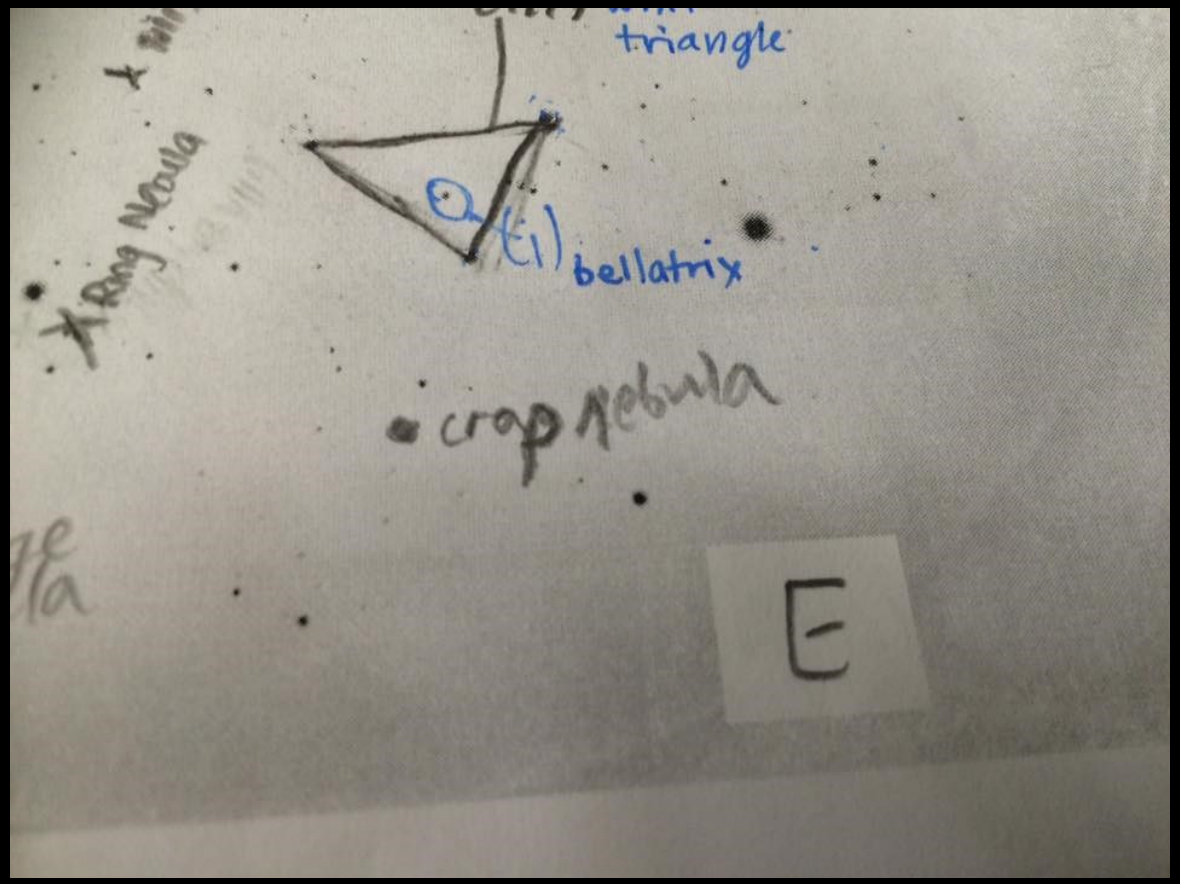


Some interesting answers…



- *"Install the stopper before the counterweights"*
- There is a reason why it is called a "stopper" :x

Some interesting answers…



- One team topped it all off and gave me a crap answer…*literally* 💩

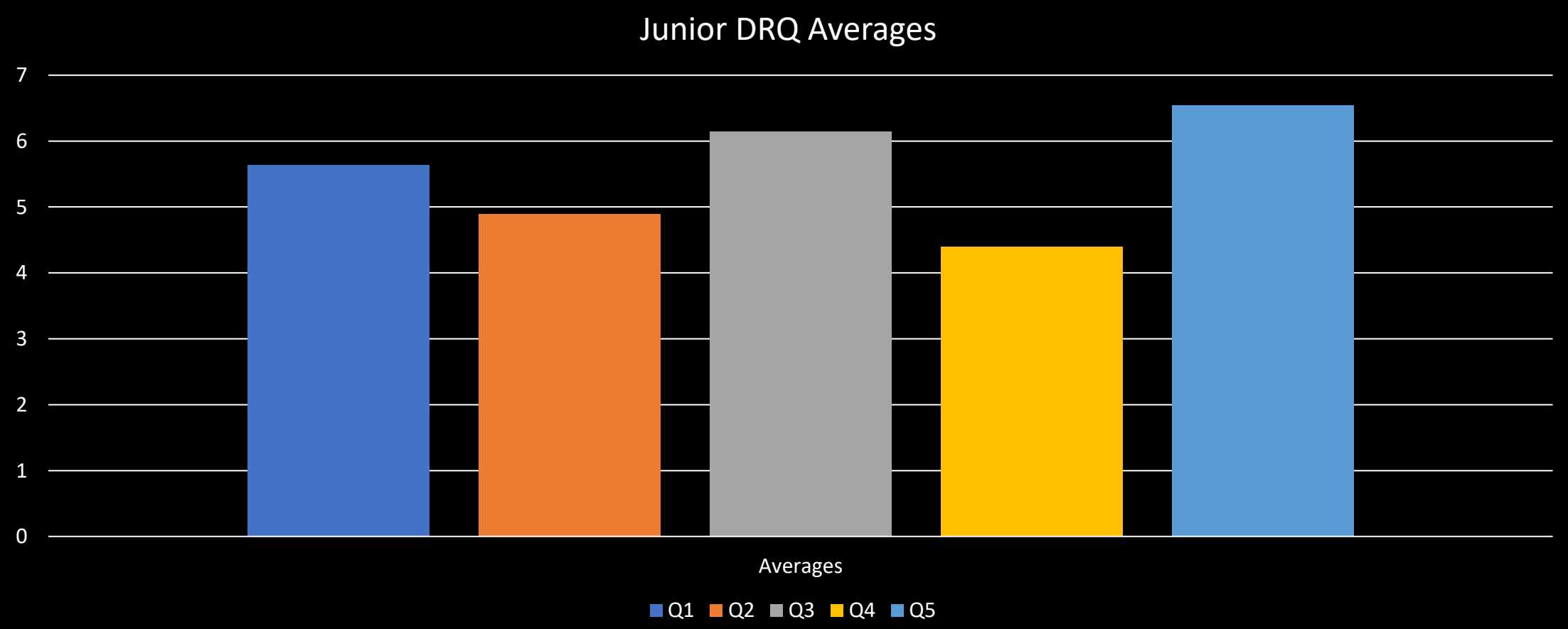
Thank you for marks for brain cells lost, as per the last 4 years :")

Hi :)
This is really hard :)

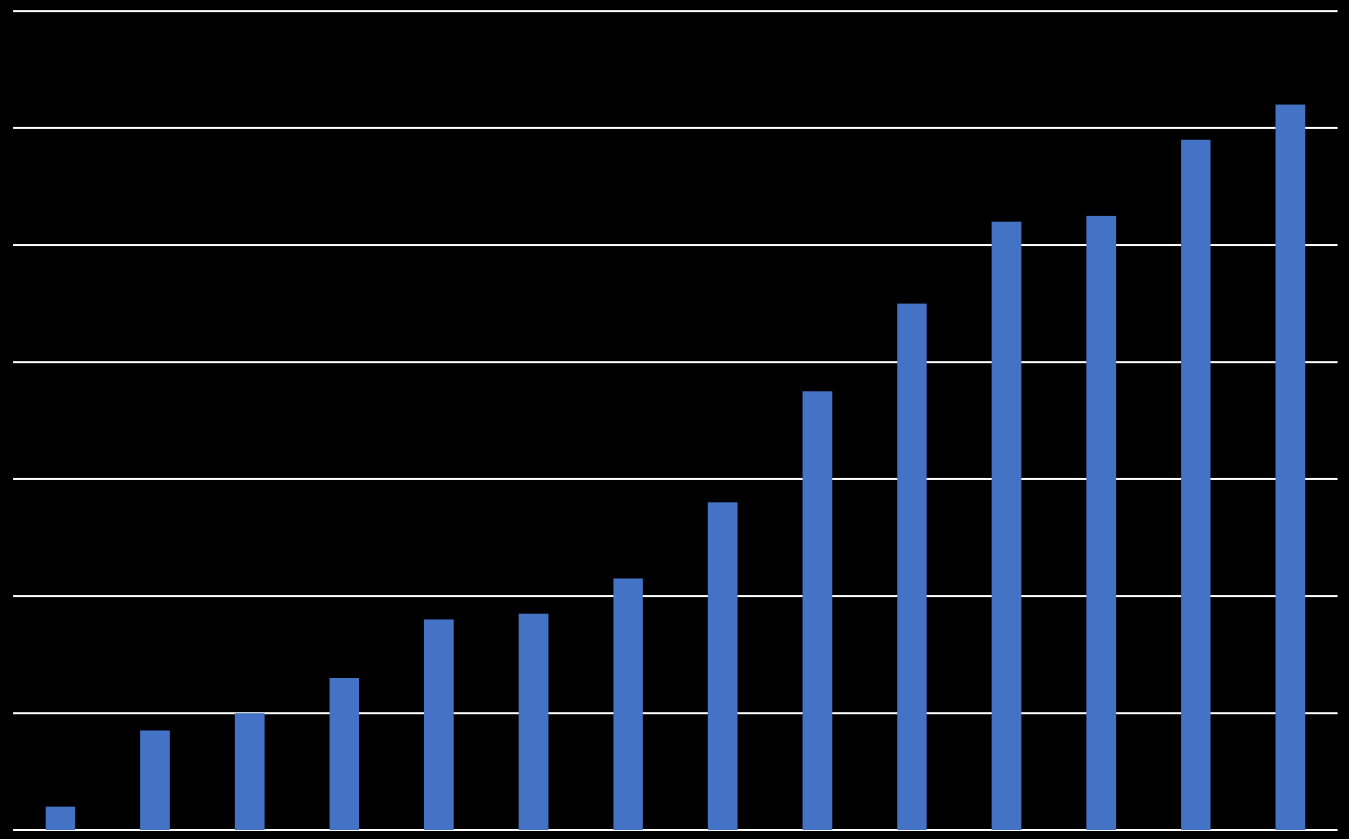
Nile maymay

have a break
have a kitty
please give
marks :)

Junior DRQ Average Score by Question



JNR DRQ Scores (Mean=30.5, SD=20.4)



SNR Observation Round

Comments

- In contrast with prior years, setup this year was rather well-done
  - Thank you for brushing up on your practical setup skills!

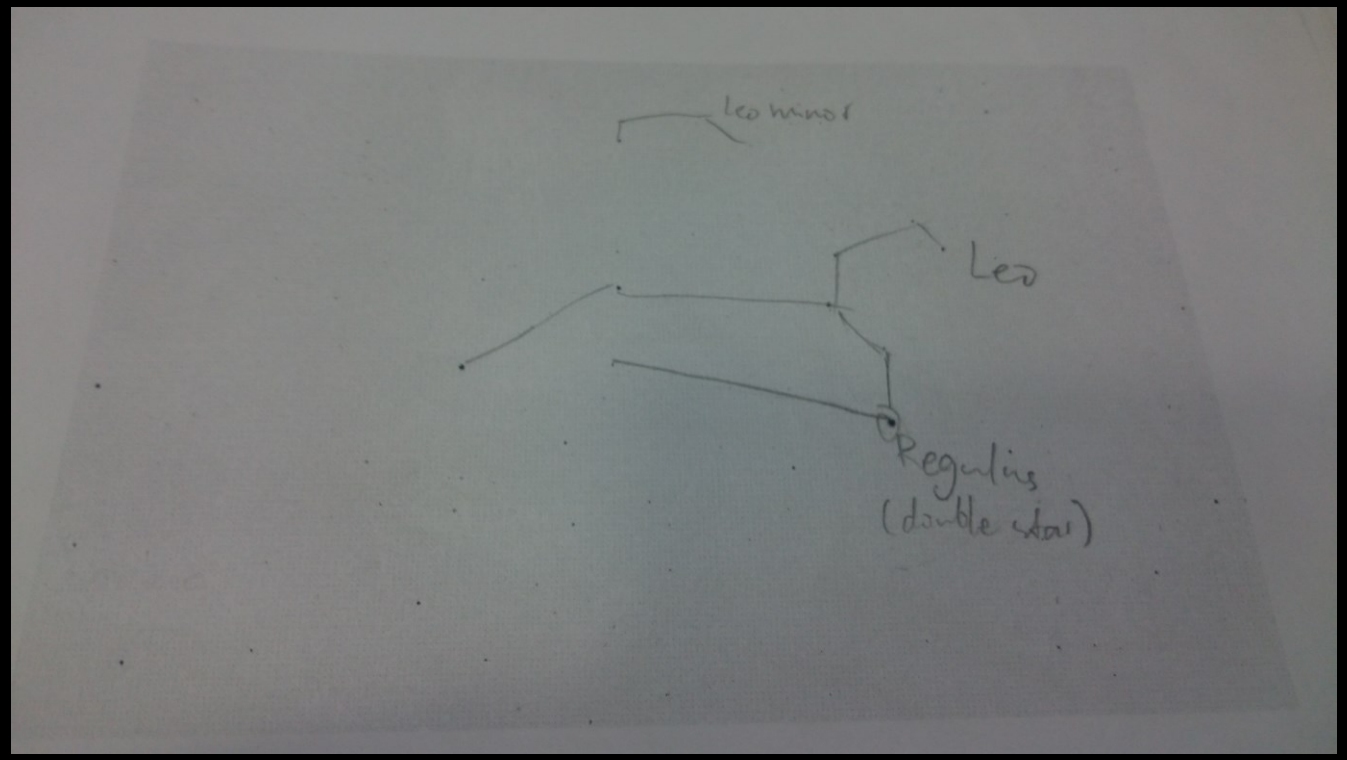
- Finder chart segment was rather uneven: please minimally observe 5 key principles while drawing these charts.

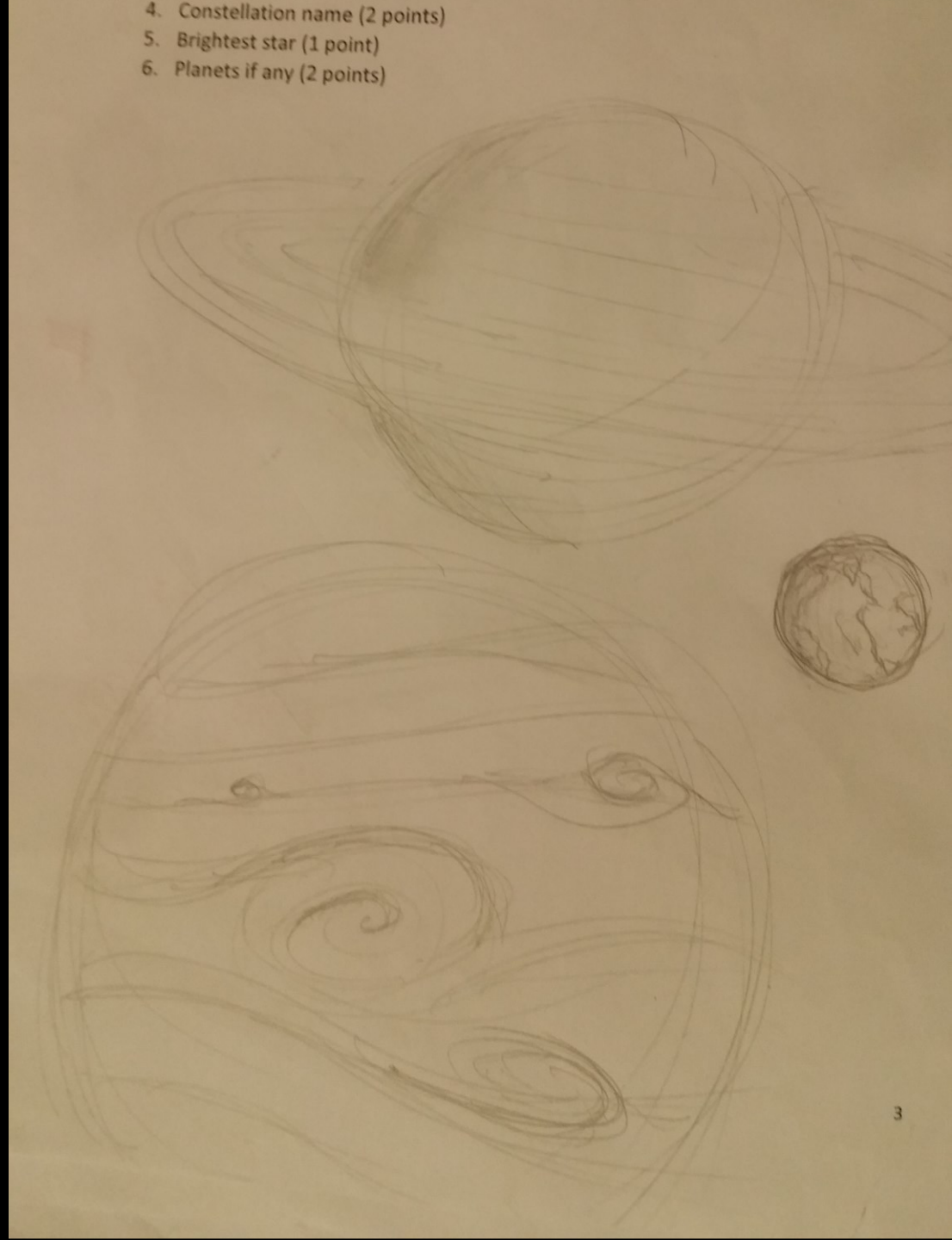
1. Cardinal directions (N/E)
2. Diagrams are drawn accurately and to scale
3. Clear instructions for slewing
4. Initial FOV and direction to proceed
5. Target position is correct and clearly indicated

Serious Matters

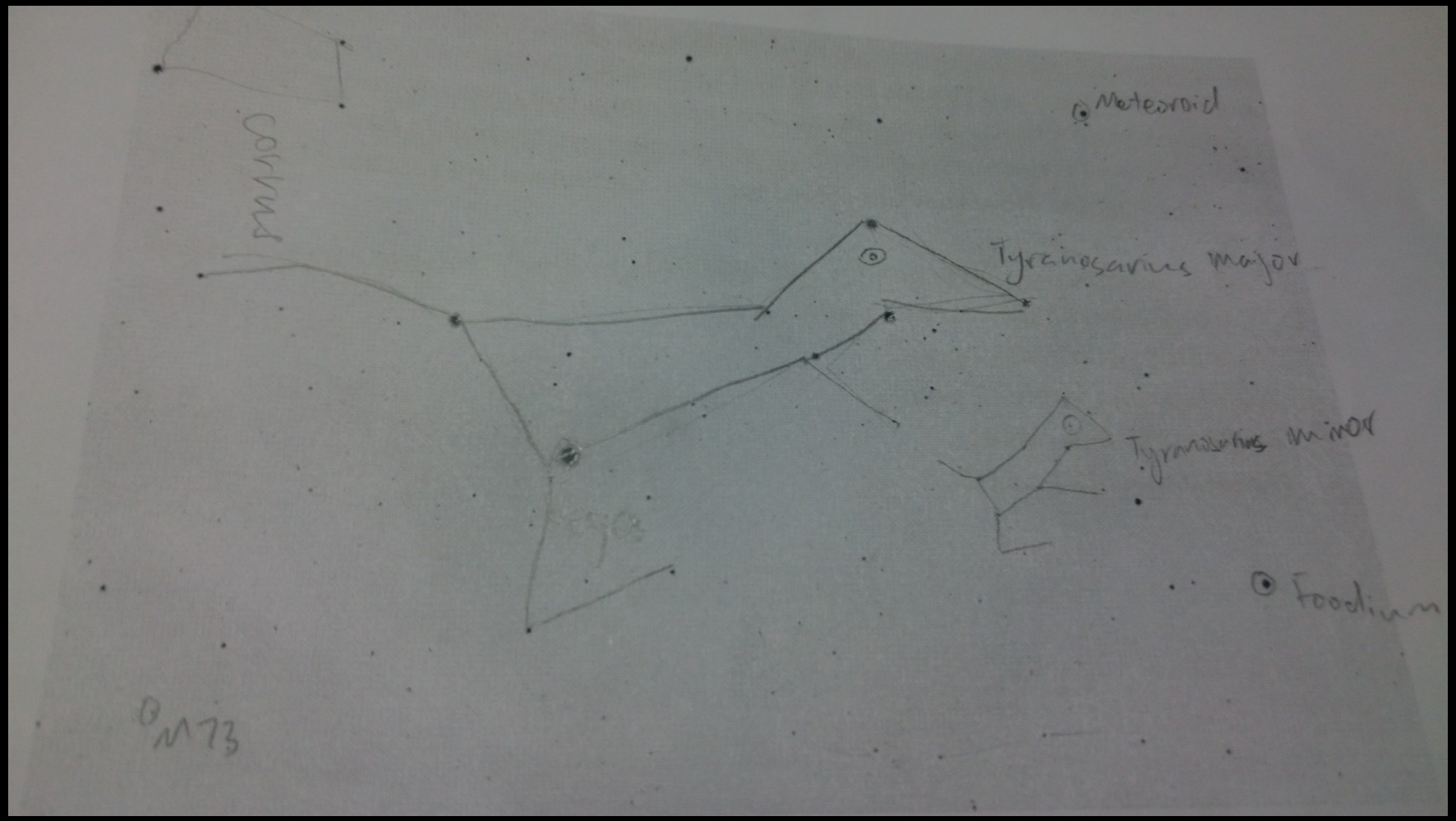
- Reports of cheating encountered
  - Removed Part 2 of Theory Paper from scores

Interesting drawings

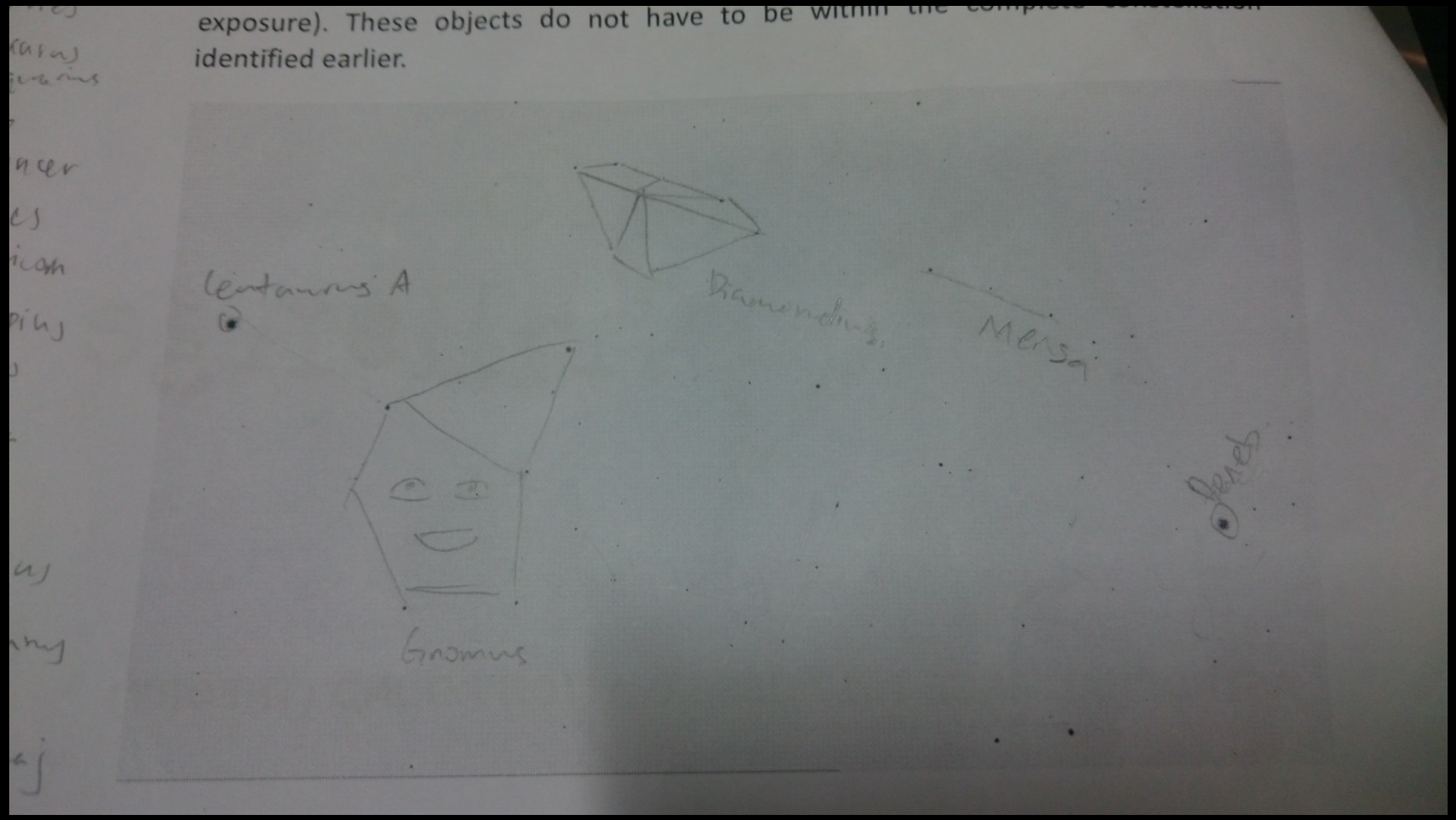




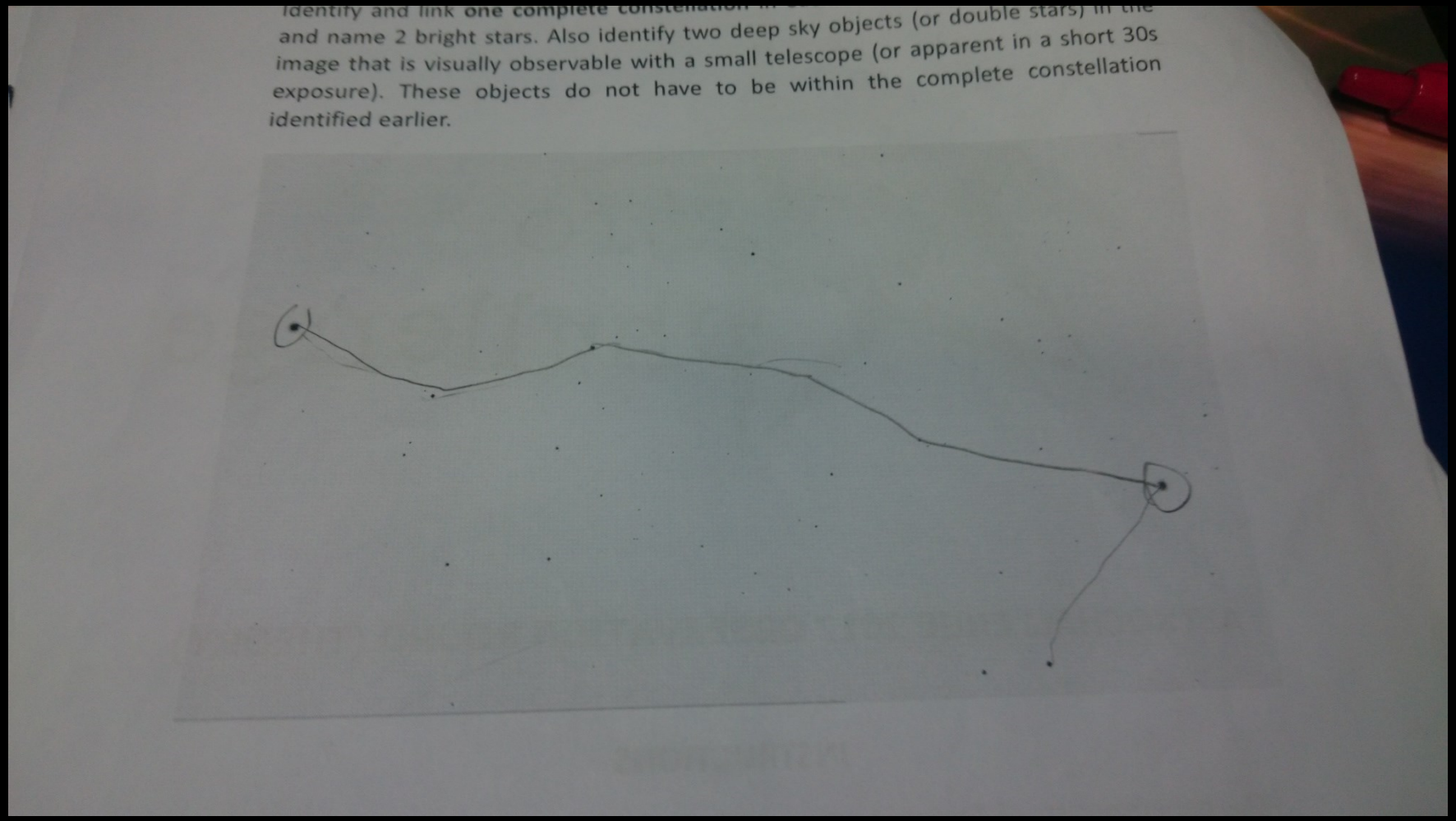
Funny drawings



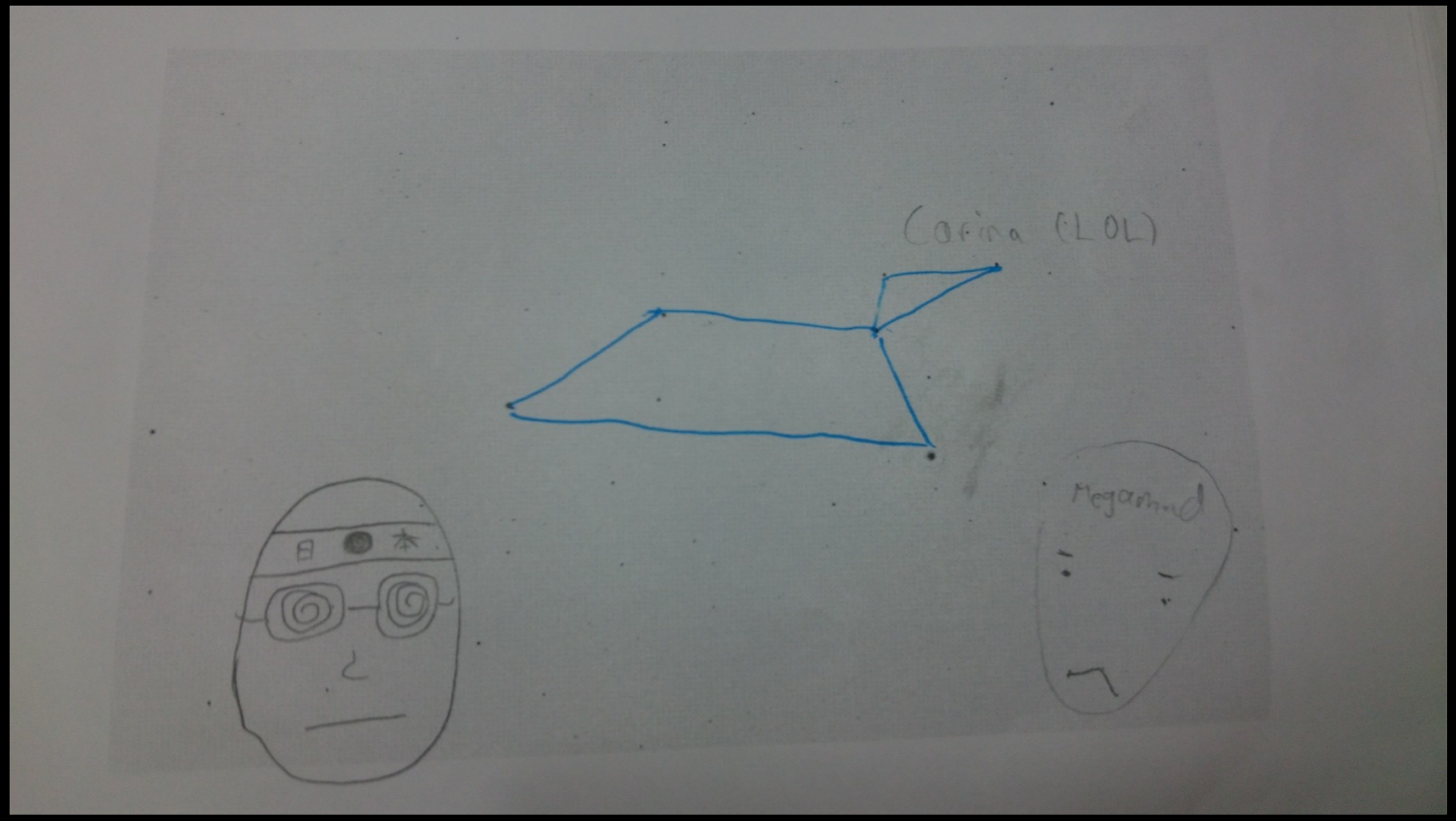
Funny drawings



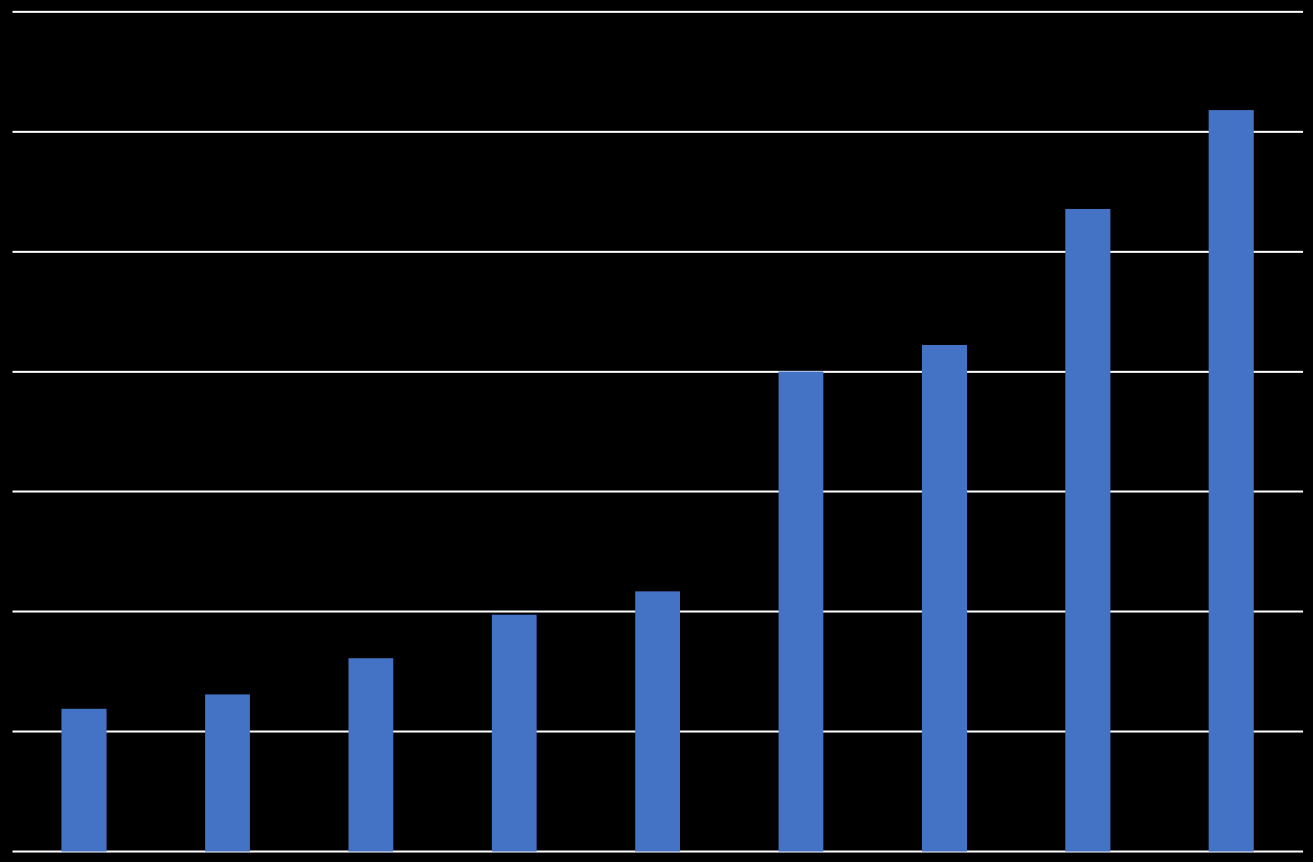
Funny drawings



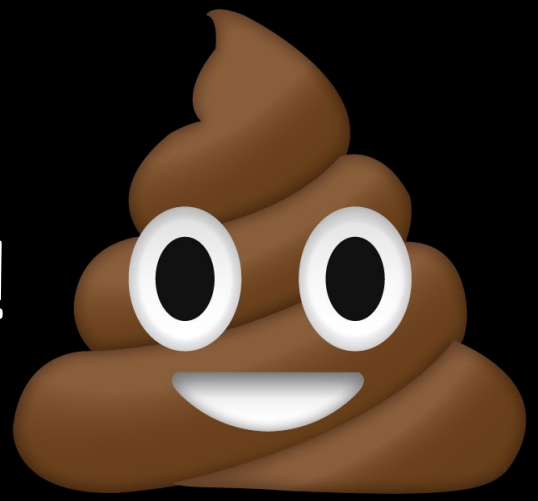
Funny drawings



Ob Round Scores (Mean = 31.1, SD = 18.7)



That’s all, Folks!



- With love, your QMs