AC2020 JNR Post Mortem

Project Round

Project Round General Comments

- Do not squeeze too much text into the poster!
  - Balance content versus readability!
  - Good aesthetic design can help in this, but only up to a point
- For a poster, choice of graphics is important
  - Does it help in understanding the content?
- Make sure you answer the question!
- Also: **please credit the source of your images!**

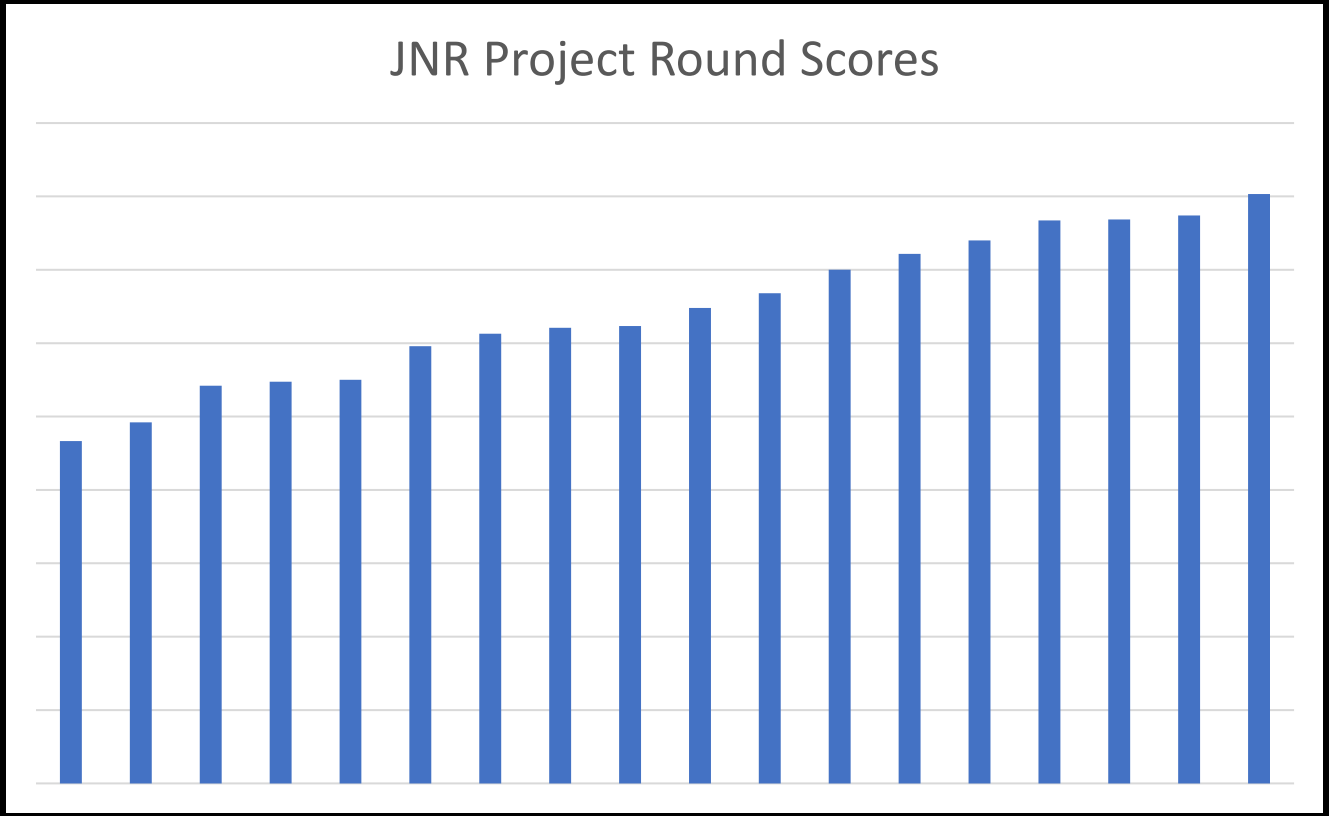
Most Attempted Question

- Teams chose a wide variety of questions, as demonstrated by the 4-way tie for this statistic:
  - Q7: In 2019, the first image of a black hole was taken. How was this image taken?
  - Q13: What are some leading theories of how black holes are formed?
  - Q15: What are some of the health risks associated with living in space?
  - Q17: What is a supernova and how is it essential for life?

- Overall, interest in black holes was very high this year.
  - Yet this topic posed dangers for Junior participants due to conceptual difficulty/ tendency to bring in unnecessary concepts like General Relativity
  - Make sure you read up before trying to tackle difficult topics!

Project Round Overall Statistics

- Mean: 64.7
- Median: 63.6
- Std. Deviation: 10.0



Individual Round

This year's "100%" question

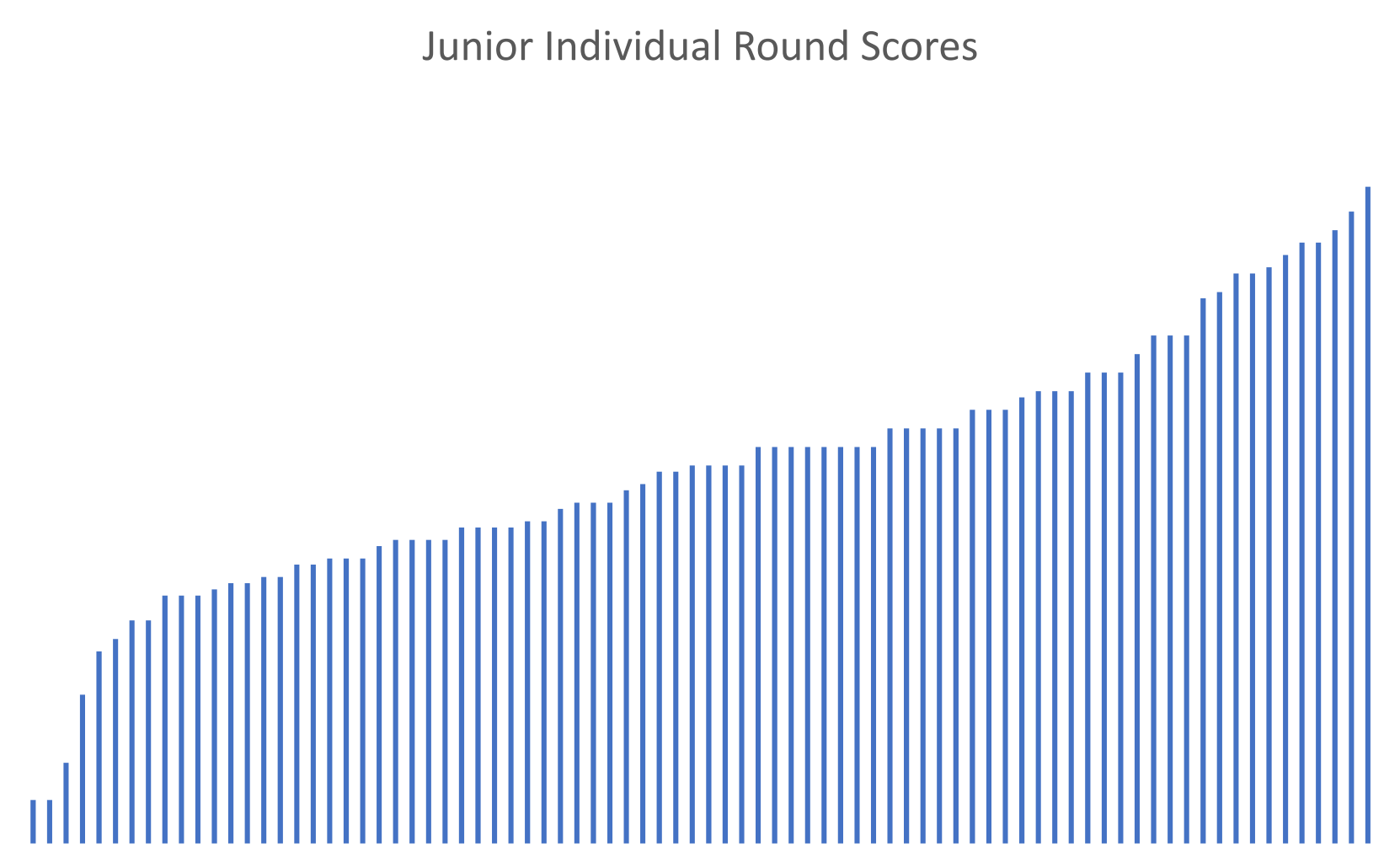
- Q25:
  - I want to take a color image of the Great Dark Spot (6600km across), using individual 10s exposures in 3 different wavelengths….
  - The question instead got the most number of blanks in the Junior Category….
    - 46.9% got this correct in the Junior Category!
    - Seniors didn't do better: only 42.8% got this correct
- Key to this question: aperture is NOT the only factor you need to consider when trying to resolve an object!

Individual Round Question Statistics

- Easiest Question: Q29
  - 84.6% correct
- Least Correct: Q44
  - 7.9% correct
  - Most popular response: the Sun lies north at local noon for a location near the Arctic Circle.
  - When you are this far north, the Sun NEVER appears in the north at local noon.
- Most blanks: Q25
- Please consult the answer scheme for solutions and explanations!

Individual Round Overall Statistics

- Mean: 60.3
- Median: 61
- Std. Deviation: 20.6



Team Round

JNR DRQ 1

A long night at Pulau Ubin

Roy Costa

General comments

- Question was the best scored out of the 5 junior DRQs with an average score of 10.83
  - Still slightly disappointing, because I am a very lenient marker
  - I understand that you are all juniors, and I mark accordingly with what AC expects from juniors. But that does not mean I look down on you (I was your age once) or will accept smokes.
- Nonetheless, the question was set to test several fundamental concepts in astronomy, but many inadequate answers were given
- Direct lifting of answers from online (esp wiki) was also present

Q1a

- This question expects participants to be able to distinguish between stars and planets in the night sky through simple observation, and is a giveaway 2 marks.
- A thorough reading of the question will show that *how* your method distinguishes them both and *how* you tell them apart are actually the same thing.
- Question requires a simple “planets will appear not to twinkle, but stars will appear to twinkle.”
  - Answering just ‘planets do not twinkle’ and leaving the marker to guess what stars do results in only 1 mark awarded
- I would like to commend schools who went on to explain this phenomenon, though the question did not ask for it. You have shown a deep understanding of the optical phenomenon.

Q1b

- Part bi had a good proportion of schools lifting answers from Wikipedia. This is highly disappointing.
- This question is 2 fold. First, participants should be able to understand blackbody radiation and its spectrum, as well as how the eye (brain) would then go on to perceive it, or simply how green+red+blue+other stuff = white
- An accepted answer would be ‘A star with a blackbody spectrum peak in green light would also emit a substantial amount of other coloured light which the eye/brain perceives as white.’

Q1b

- Part bii is a giveaway question, related to the eternally asked question “why is the sky blue.”
- An acceptable answer would be “The atmosphere scatters shorter wavelength light such as blue, which leaves the Sun appearing yellow”
  - A more laconic answer of “due to Raleigh scattering of blue light” is also acceptable
- It should be noted that there is no such thing as “higher wavelength” or “lower wavelength”. The proper term is ‘longer’ and ‘shorter’. Use higher and lower for frequency.

Q1c

- This question is meant to separate the good schools from the excellent schools, requiring the connection between the ecliptic and the invariable plane.
  - Question also requires the underlying physical reason for planets all lying on (approximately) the same plane, which many did not address.
- Your answer should contain 3 parts:
  - Planets all seem to lie on the same line in the sky (the ecliptic) as they lie on roughly the same plane in the solar system
  - This is a result from the formation of the solar system, as the planets formed from a protoplanetary disk
  - Which due to conservation of angular momentum, settles into a disk shape from a spherical cloud
- I did not expect juniors to explain the gritty details of how conservation of angular momentum leads to a disk shape, but was heartened to see a few schools who managed to. Kudos to those who did.

Q1d

- This is another giveaway question, which in fact uses the same concept in 1bii
- The light that reaches the moon during a lunar eclipse has to pass through Earth’s atmosphere, which scatters short wavelength light. This leads to the Moon appearing red.
- I will close 1 & 1/2 eyes and give those who say that the light is “the sunrises and sunsets of Earth striking the Moon” full marks because despite the crudely phrased answer, is technically correct.

Q1e

- Part ei and eii is in my opinion the only really difficult question in this SAQ, requiring slightly more than what I would expect from juniors. Nonetheless, there were schools who answered well. But, I have chosen to mark this question leniently because of its difficulty.
- Ei calls for “the name of this phenomenon and the cause of it”.
  - All of the following names are acceptable: Tidal locking, synchronous rotation, gravitational locking, synchronous orbit
- It is the *cause* that I am really interested in. I did not ask for what results from tidal locking. I gave you that in the question already! Schools who answered “… leads to the Moon only ever showing one side to the Earth” did not understand the question requirement.

Q1e continued

- Because this is a junior DRQ, I accept ‘layman’ explanations, I do not need a master’s level thesis into tidal mechanics.
- “Earth’s gravity stretches and squeezes the Moon, causing tidal bulges – pulling on different parts of the Moon with different strengths. This results in a net torque causing the tidal bulges of the Moon be aligned to the Earth-Moon line throughout the course of the Moon’s orbit, causing tidal locking.”
- However, as you can see from answers I gave full marks to (end of section slides), I accepted answers which contained the gist of the explanation that were not as ‘eloquently’ explained.

Q1e continued

- Part eii is in my opinion the hardest part in this question, so please do not be disheartened. There were some QMs who could not answer this as well.
  - This was meant to be an mental exercise for you to apply your physics understanding
  - As a result, I accepted most logical answers, even though it might not be strictly from Moon's rotational energy
- The perennially popular duo of "heat and sound" has made their return. I will accept heat here, but not sound. Even though it is true that there are moonquakes caused by tidal interactions, a simple answer of "sound" is too vague for me to award marks.
- A uni physics major may catch me for accepting the following answers, but I have accepted
  - Thermal dissipation/heat energy, speeding up of Earth's rotation, Moon's orbital momentum, vibrational dissipation through geological (selenological) disturbances (moonquakes or even earthquakes)

Q1e continued

- The energy of the tides here on Earth **do not** come from the Moon! (or the Sun)
  - It comes from the rotational energy of the Earth!
  - The Moon does not ‘do work’ to raise the tides. From the Moon’s frame of reference, the tides are static, the Earth rotates under it.
- I had said I would mark this part leniently but this is too far away from the question requirement.

Q1f

- Finally another giveaway question which I expected everybody to answer correctly
- “The sun is too light” is entirely acceptable.
- I have also seen misconceptions when marking this part (not relevant to question, but I would still like to clear these up)
  - The core of the progenitor star must be above 1.44 $M_\odot$ to stand a chance to go supernova. This value is not for the star as a whole. That is somewhere around 9-12 $M_\odot$

Q1f

- I honestly expected a majority of schools to get full marks for fii. The question asks for measuring distances to visible stars in the night sky
- Stellar parallax and trigonometric parallax are **the same thing**. Spectroscopic parallax (photometric parallax) is the different one as it does not use parallax at all.
- Variable stars is also an accepted answer
- How could you use redshift (Hubble's constant) to measure distances to visible stars in the night sky? Even if you interpreted "visible stars" as stars visible through a telescope, the entire Local Group of galaxies do not exhibit significant redshift due to mutual gravitational interaction! Could you possible see (other than through freak Einstein lenses) individual stars more than 50 million ly away? Please think thoroughly before smoking answers
- "Standard candles" is a bad bad smoke. Standard candles is a concept, not a singular thing.

Q1g

- A moderately challenging question, but in essence a simple factual recall.
- The name of the phenomenon is any of the following: precession of the equinoxes, axial precession or simply just precession. Orbital precession however is not acceptable because that is an entirely different thing.
  - Procession is a completely different thing; it’s not even astronomy. Watch your spelling
- “Why does this result in the pole star changing?” Many left this part blank. Precession results in the north pole tracing out a circle across the celestial sphere over a period of 26 000 years, resulting in it pointing to different stars at different points of this period.
  - I don’t expect you to know the period, just that the north pole traces out a circle over time, causing it to point to different stars. (In essence, what precession is)

Summary

- All in all, this question has its easy and challenging parts, and I was both happy to see certain schools go above and beyond the question requirements, and saddened to see some schools go full smoke bomb on me for the giveaway questions.
- What you all know, however, is already far more than the average person, so you can take pride in that. Schools that scored under 9 should take the time to brush up on basic concepts. To schools who scored 15 and above, well done!
- I'll end off with some excellent answers from some schools, as well as some… not so excellent ones for every part, so you know how I have marked your answers.
- Finally, massive props to RIJT1 for a 20/20 score! Honorable mentions include BPGHSJT6, RIJT2 and RIJT4.

1. (a)

Stars twinkle while planets do not. Stars are more distant from Earth, hence their light appears almost as a single point, making it more susceptible to atmospheric turbulence that causes distortions to the light path and causes twinkling. Planets, although smaller, are much closer, hence their light appears as a disk and not a point. This means that localised atmospheric turbulence is not as significant, and distortions of light from different points on the disk will cancel out, preventing twinkling.

Excellent answer, terrible handwriting

Date:

Stars would twinkle in the sky, however planets do not, thus it is easily distinguishable according to ~~it~~ whether it twinkles or not.

Still entirely acceptable

There are no green stars because the colour of a star is more or less given by a blackbody spectrum, which never looks green However, there are a few stars that appear green to some observers. This is usually because of the optical illusion that a red object can make nearby objects look greenish.

In astronomy, there is truly no green stars, because the color of a star is more or less given by a black-body spectrum - which never looks green - However there are few stars which appear green - This is an optical illusion that a red object can make nearby objects look greenish

At the moment there are no truly green stars as the color of a star is given by a blackbody spectrum, which never looks green. However, there are a few stars that appear green to observers. This is usually because of ~~op~~ an optical illusion where red objects ~~look green~~ make nearby objects look greenish.

There are no green stars because the colour of a star is given by a black-body spectrum, which never looks green.

The colour of the star is given by a black-body spectrum which never looks green

In astronomy, a **green star** is a white or blue star that appears green due to an optical illusion. There are no truly green stars, because the color of a star is more or less given by a black-body spectrum, which never looks green.[1] However, there are a few stars that appear green to some observers. This is usually because of the optical illusion that a red object can make nearby objects look greenish. There are some multiple star

Yes, we can tell

(i) Since a star is a black body, when it emits green light then it also emits and blue and red light. The human visual sensory system interprets this as white light.

Simple, straight to the point

b) i) The colour of light stars emit are dependent on its place in the black body spectrum. Black body radiation would determine the wavelength of light stars emit which in turn decides its colour and green light emited by certain stars, would usually be overwhelmed by other lights of longer wavelengths such as red, hence causing stars to be unable to appear green.

Still acceptable, and super neat

(b) (ii) The colours with shorter wavelengths such as green, blue, and violet are scattered out more easily by the earth's atmosphere, leaving behind only the colours with longer wavelengths such as red, orange and yellow. Thus, the sun appears yellow.

Beautiful answer, beautiful handwriting

(c) The three planets as well as the moon all lie along or close to the ecliptic, which is where the sun appears to move through. This is because during the formation of the Solar system, the planets and moon form from the same flattened protoplanetary disk. As such, angular momentum must be conserved, meaning that the planets and moon will move in the same plane as the original protoplanetary disk.

Very good answer

(c) All the planets (and the moon) lie roughly in the same plane (except Mercury). The reason is related to the formation of the solar system. The solar system used to be a giant molecular cloud, which spun slowly. Disturbances caused the cloud to collapse under its own gravity. Due to the conservation of angular momentum ($L = mvr^2$), the portion of the cloud perpendicular to the axis of rotation started spinning faster, and due to inertia, overcame gravitational force and became wider than other portions. The rest of the cloud collapsed, forming a disk, which would be the planes of the planet's orbits location.

Good!

The Earth's atmosphere scatters red light the least, so the light reflected off the moon appears to be red after passing through the atmosphere to reach us

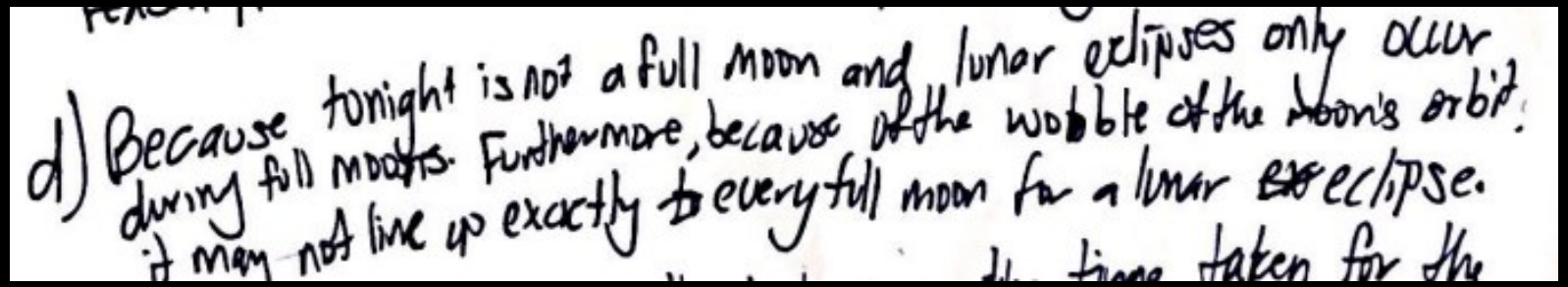
Acceptable

The moon is fully in earth's shadow. At the same time, a little bit of light from Earth's sunrises and sunsets falls on the surface of the moon. Because the light waves are stretched out, they look red. When this red light strikes the moon, it also appears red.

Also acceptable

d) The moon turns red during a lunar eclipse because of Rayleigh scattering. When the moon is eclipsing, the ~~sun~~ Earth moves infront of the moon ~~blocking~~ and the light from the sun to the moon is mostly blocked, except for those that pass through earth's atmosphere, where ~~there was~~ the presence of dust particles, water vapour etc, scatters the ~~light~~ white light into their colors. Since red light has a large wavelength, it is less scattered and continues to reach the moon and reflect off it, making the moon look red.

Good answer but terrible terrible handwriting



d) Because tonight is not a full moon and lunar eclipses only occur during full moons. Furthermore, because of the wobble of the moon's orbit, it may not line up exactly to every full moon for a lunar eclipse.

Misinterpreted the question!

e)(i) This phenomenon is known as tidal locking.
Earth's gravity acts more strongly on the surface
of the moon pointing towards us as compared to
the surface pointing away from us, leading to the
moon bulging towards the Earth slightly. As the moon rotates,
the bulge points away from the Earth, causing
a net torque on the moon that acts to slow its rotation
until the moon rotates once for every orbit it makes, thus only
showing one side.

Excellent!

Heat energy, frictional energy, gravitational energy.

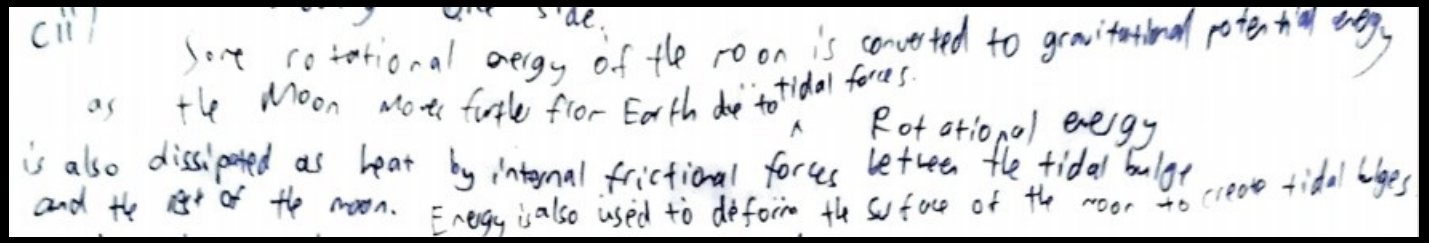
What in the world is frictional and gravitational energy?

(ii) Rotational momentum of the Moon has been lost due to energy being converted into heat and sound, and the moon losing mass to space, resulting in a loss of momentum.

I didn't know the moon flung bits of itself into space

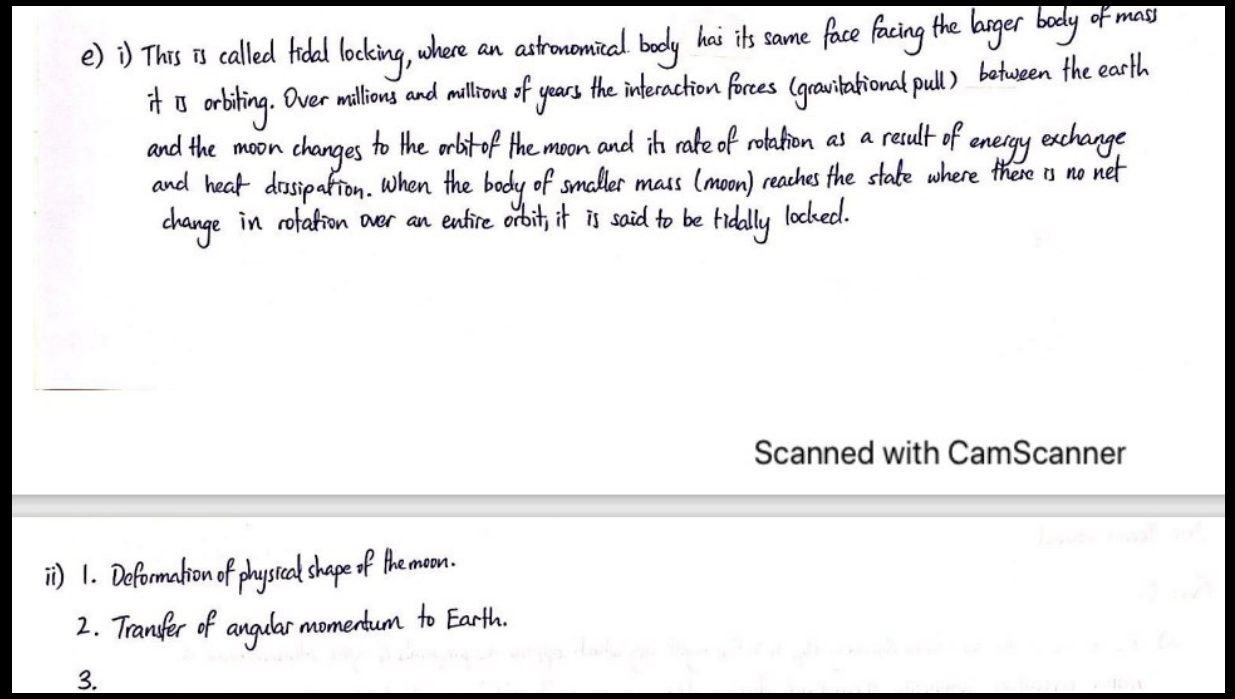
(ii) It is converted to kinetic energy

Smoke out! Smoke out!!


Some rotational energy of the moon is converted to gravitational potential energy as the Moon moves further from Earth due to tidal forces. Rotational energy is also dissipated as heat by internal frictional forces between the tidal bulge and the rest of the moon. Energy is also used to deform the surface of the moon to create tidal bulges

If you can read what is written, it is the only fully acceptable answer for eii

1. GPE of moon (orbital momentum)
2. Heat energy
3. Selenological deformation


e) i) This is called tidal locking, where an astronomical body has its same face facing the larger body of mass it is orbiting. Over millions and millions of years the interaction forces (gravitational pull) between the earth and the moon changes to the orbit of the moon and its rate of rotation as a result of energy exchange and heat dissipation. When the body of smaller mass (moon) reaches the state where there is no net change in rotation over an entire orbit, it is said to be tidally locked.

Scanned with CamScanner

ii) 1. Deformation of physical shape of the moon.

2. Transfer of angular momentum to Earth.

3.

Nooooo you put heat dissipation in ei but not in eii???
You could have gotten full marks!!

The Sun is not as massive as Betelgeuse, so it will burn out its fuel much slower and also is physically incapable of going supernova.

Acceptable

(f)(i) The sun is too small to end its lifetime as a blackhole thus will never go supernova

Acceptable

f (i) Astronomers believe that the Sun is not massive enough to go supernova.

Concise

Astronomers use stellar parallax and trigonometric parallax to measure distances to visible stars in the night sky.

Astronomers estimate the distance of nearby objects in space by using a method called stellar parallax, or trigonometric parallax.

Same thing people, same thing

Another way to measure distance is redshift, this is due to two different effects and expanding universe and doppler shifting. Our universe expands at an increasing rate and hence from our perspective, everything seems to be receding away from us at a certain speed. As these objects move away, the light emitted by them will travel towards us and as it does, a phenomenon known as the doppler effect occurs, where the light wave gets 'stretched', causing it to redshift as it loses energy. The redshift can also be used to measure the distance between us and a distant object in the universe.

Almost perfect explanation of redshift
but completely misses question context

(ii) Stellar parallax, Photonics

How does photonics play a role??

Q1. (iii) Binary components using gravitational constant and

I am kept in suspense till this day

1) Stellar ~~parallax~~ parallax. The distance between nearby celestial objects can be measured by measuring a star's apparent movement against the background of more distant stars as Earth revolves around the Sun.

2) Triangulation. By getting the angle to a planet or star from 2 different vantage points, we can calculate the properties of the triangle and thus the distance to the star.

How to say the same thing twice 101

ii) 1. Parallax — by measuring a star's apparent movement against the background of more distant stars as the Earth revolves around the Sun.

2. Surface Brightness Fluctuation — by estimating the absolute luminosity of the star from its colour and comparing it with the apparent luminosity to deduce the approximate distance of stars.
(Spectroscopic parallax)

Excellent!

8.) ii) Parallax and comparing brightness to a standard candle (e.g. (cephEid variables)

Standard candles but gave eg

(ii) Spectroscopic parallax and trigonometric parallax

Concise!

Qn 1g) As polaris is currently aligned with the axis of our planet, it is the pole star and it will not change its position in our night sky for a few thousand years. However due to our moon and the bulge at the equator, the axis is prone to moving off slightly from its original spot. Over time, these small changes will point the axis away from polaris and change the Earth's pole star.

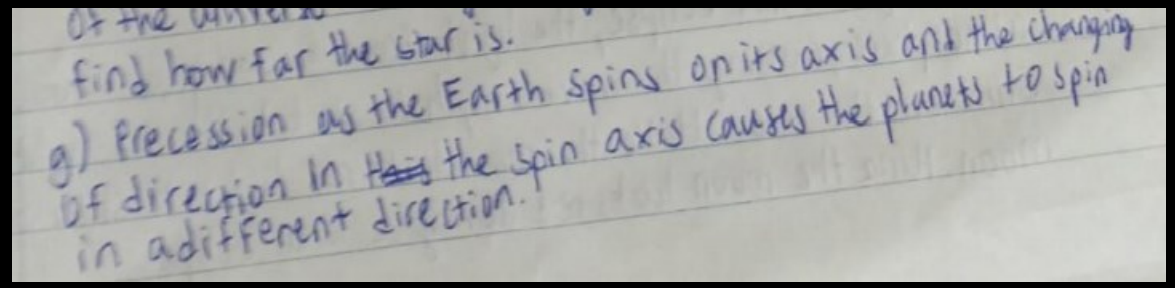
Good!

(g) Axial precession of Earth

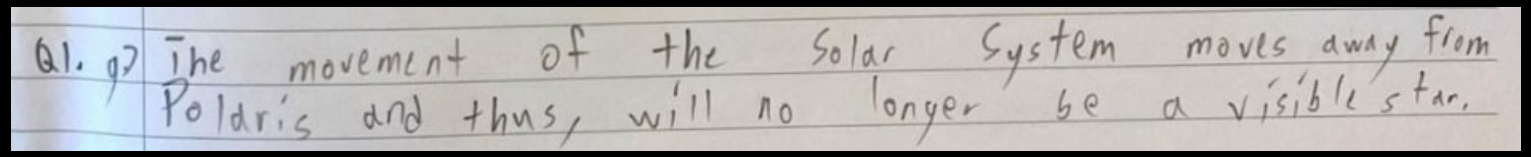
Earth's rotational axis is also rotating in a circle with a period of 26000 years

This causes the NCP to change and hence the pole star to change

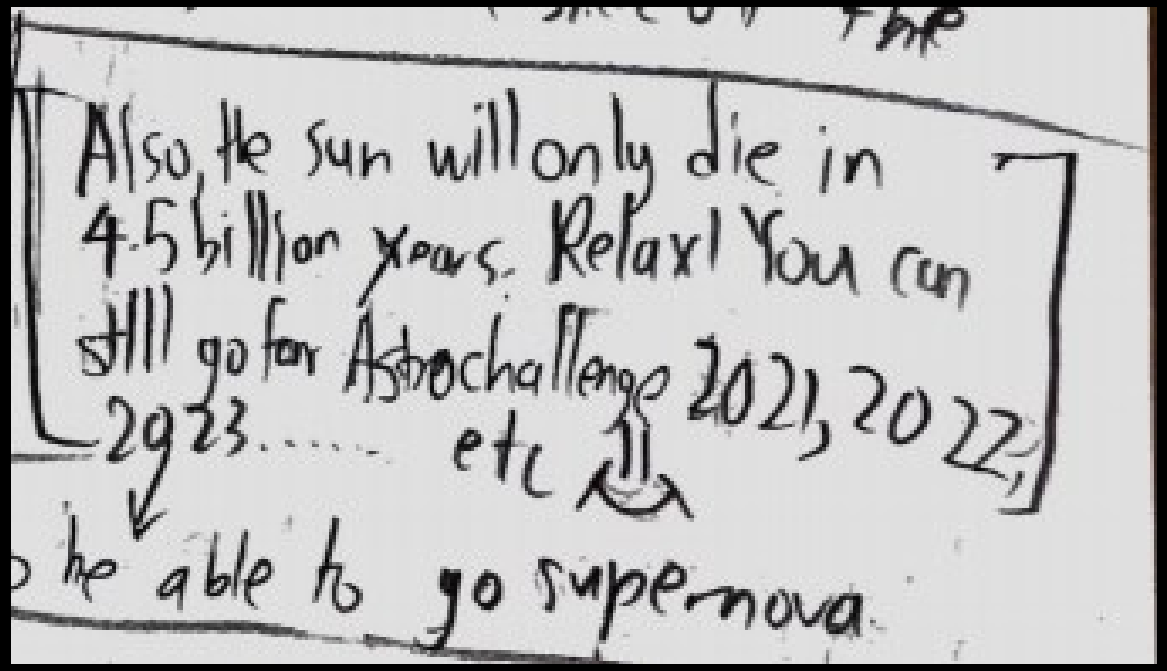
Concise!


of the universe
find how far the star is.
g) Precession as the Earth spins on its axis and the changing of direction in ~~their~~ the spin axis causes the planets to spin in a different direction.

Wait… what?


Q1. g) The movement of the Solar System moves away from Polaris and thus, will no longer be a visible star.

Where are you going with this?
Question says 2-3000 years' time!



Completely relaxed after this

THANK YOU ALL FOR YOUR ENTERTAINING ANSWERS AND ALL THE BEST FOR YOUR FUTURE ENDEAVORS!

JNR DRQ 2

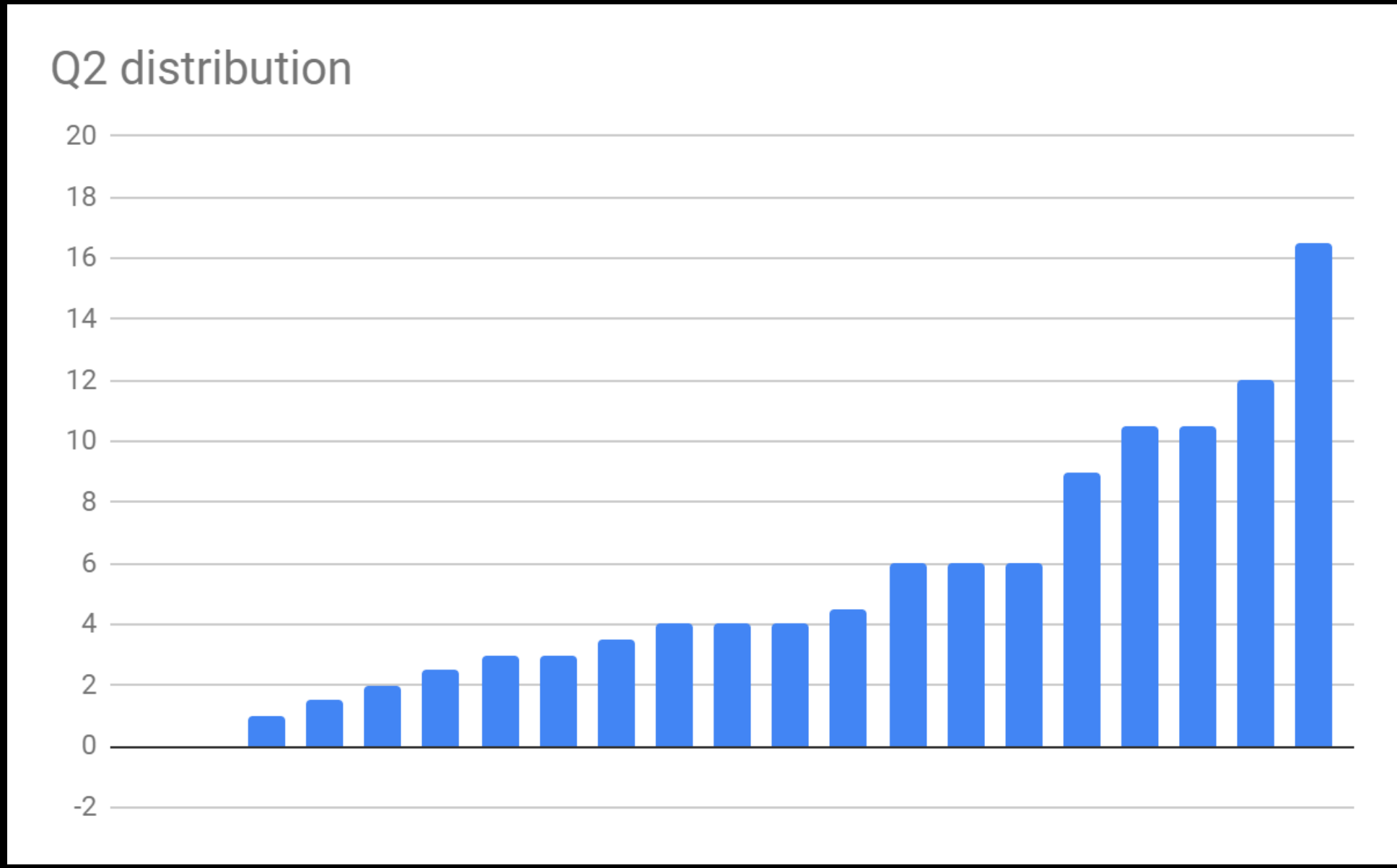
How to land on the moon

Nicholas Phung

Introduction

- It was supposed to be an easy question
- Not many of you did it in full however.
- Many thought too much of the question

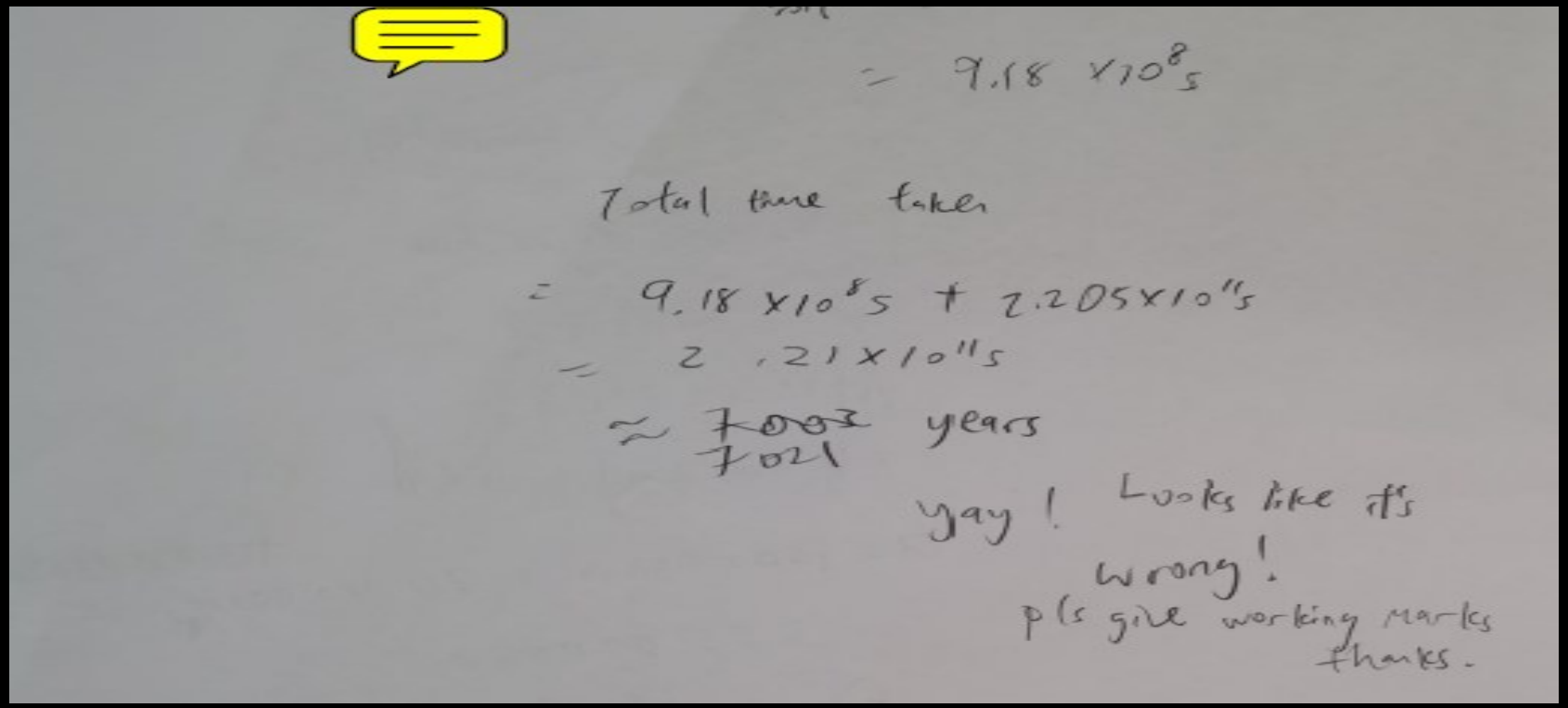
Summary of scores



Average = 5.21/20
High= 16.5/20
Low= 0/20
Median = 4/20

Some suggestions

- Usually, when you recognize impossible answers, recognize your own mistake and move on
- For Eg to calculate the time needed for the spacecraft to touchdown on the moon:



Good Examples

- Actually bothering to explain why the equation is used

Q2. (a)

By conservation of energy,

$$(K+U_g)_{initial} = (K+U_g)_{final}$$

Since $K_{final} = 0$ and $U_{g\,final} = 0$,

$$\frac{1}{2}mv^2 + \frac{-GMm}{r} = 0$$

$$v_{minimum} = \sqrt{\frac{2GM}{r}}$$

On the other hand…

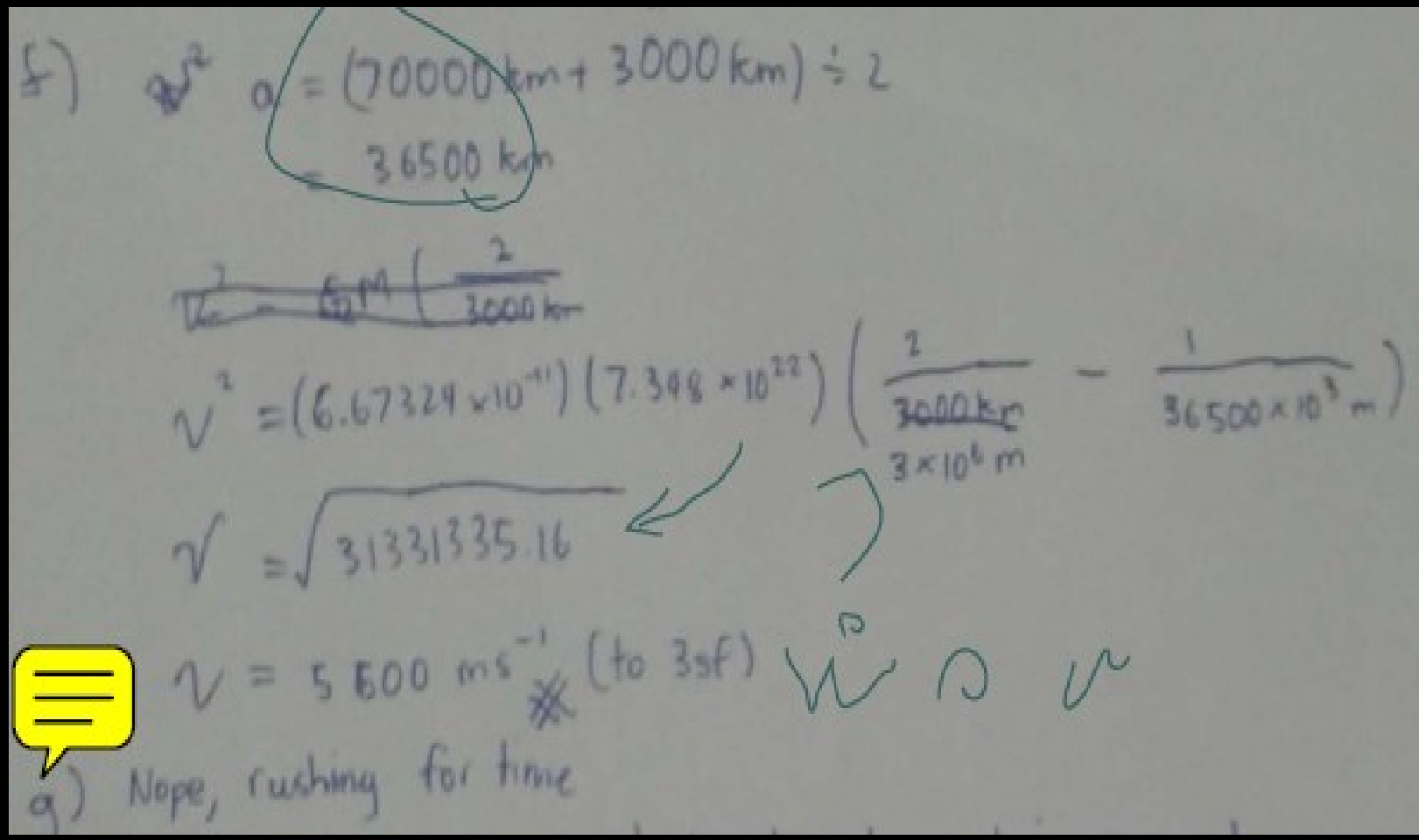
Careless mistakes

- To calc landing speed:

- For ref:

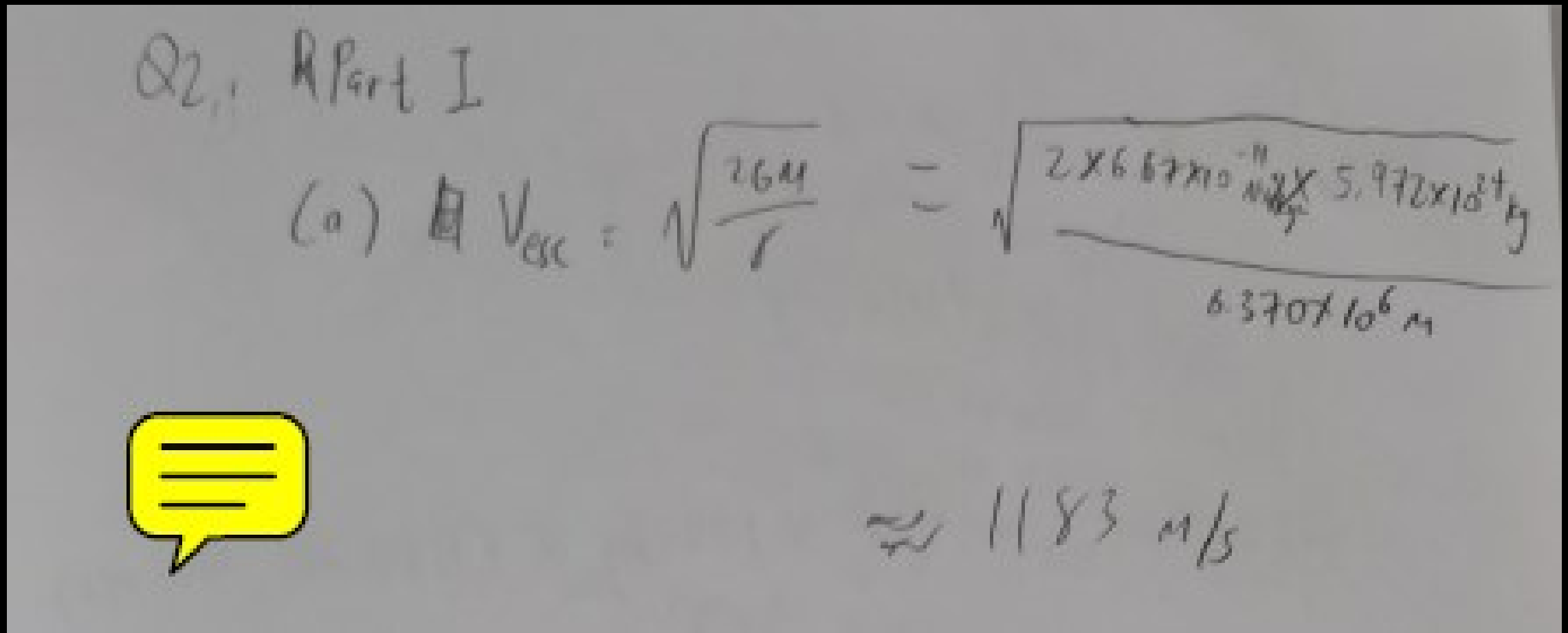
V escape for moon

Is 2238m/s…



Careless mistakes

- Missing zeroes can have huge differences



Also

Nonsense units

(b)

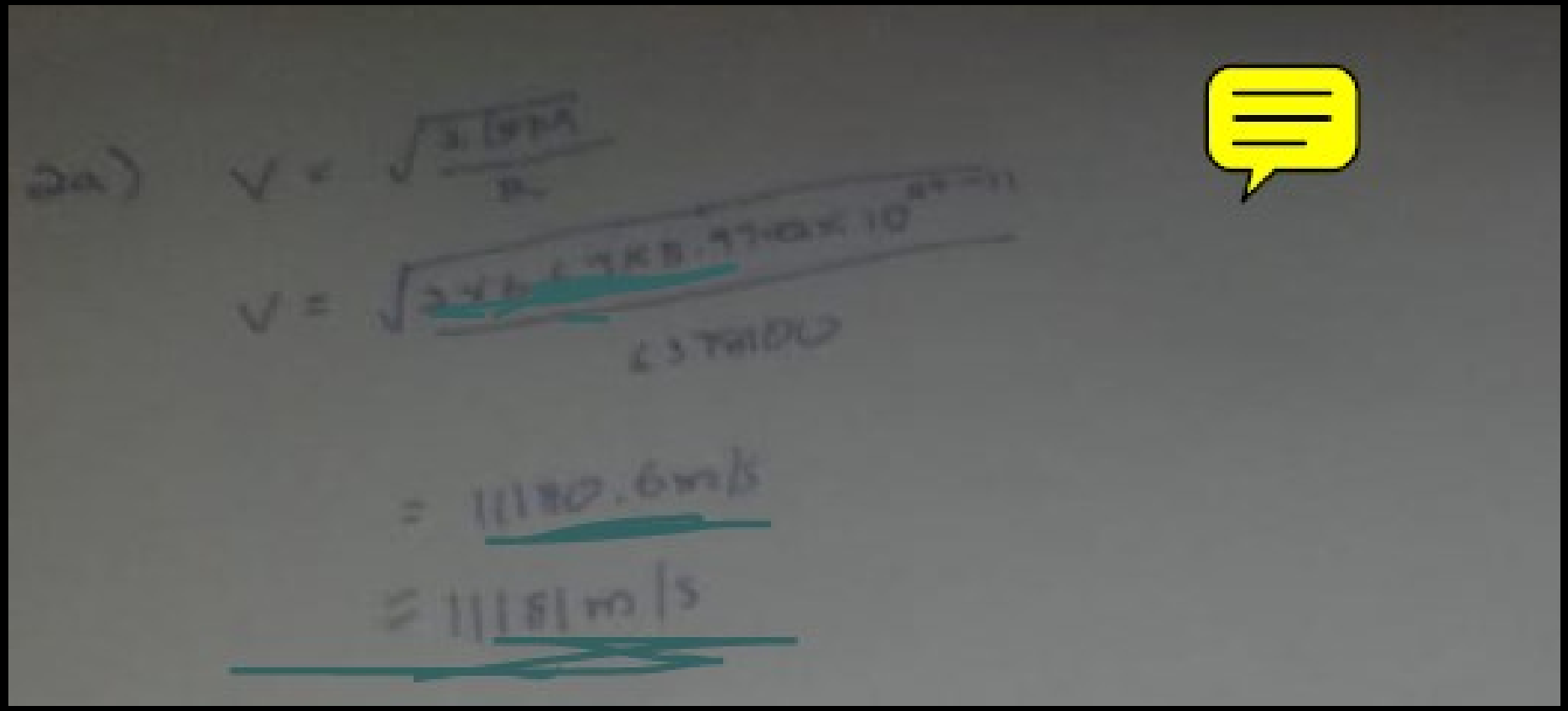
$$\text{Rotational speed}_{\text{Earth}} = \frac{2\pi r_{\text{Earth}}}{\text{Sidereal Period}}$$

$$= \frac{2\pi \times 6.370 \times 10^{6}\,\text{m}}{24\,\text{h} \times 60\,\text{min} \times 60\,\text{s}} \; ?$$

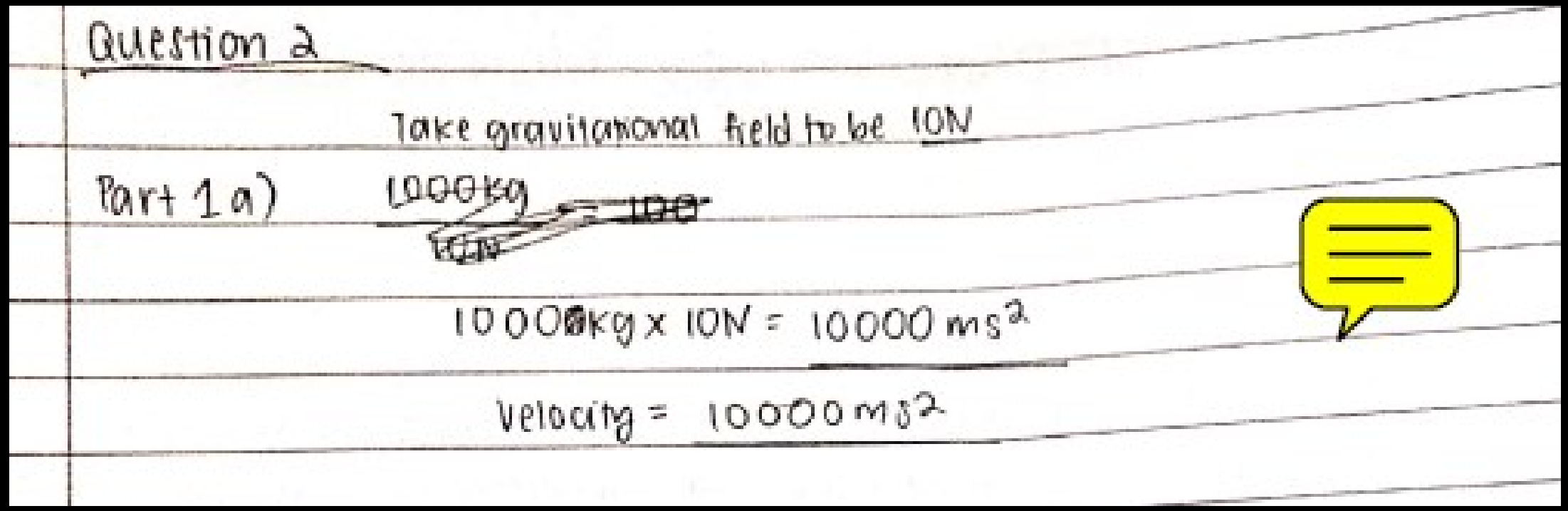
$$\approx 463\ \text{m/s}$$

~~This speed is~~ can be used as momentum Earth's rotation

Significant figures



Examples which were quite embarrassing…



Question 2

Take gravitational field to be 10N

Part 1 a) 1000kg

1000kg x 10N = 10000 ms²

Velocity = 10000 ms²

- Spot the mistake

Question 2

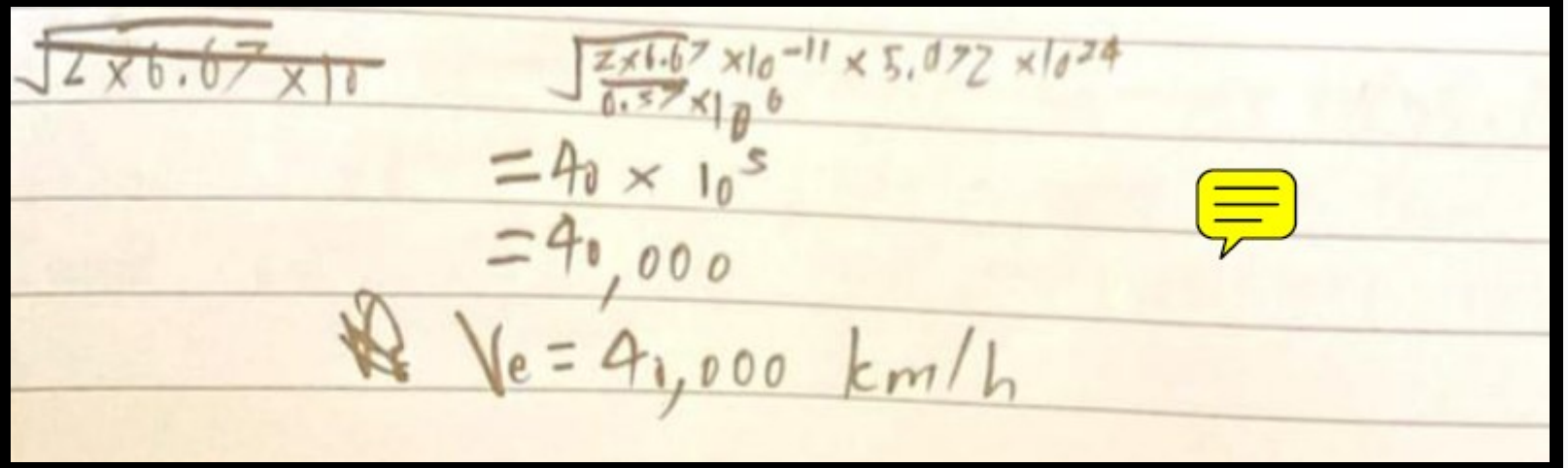
2a) Escape velocity $= \sqrt{\frac{2GM}{r}}$

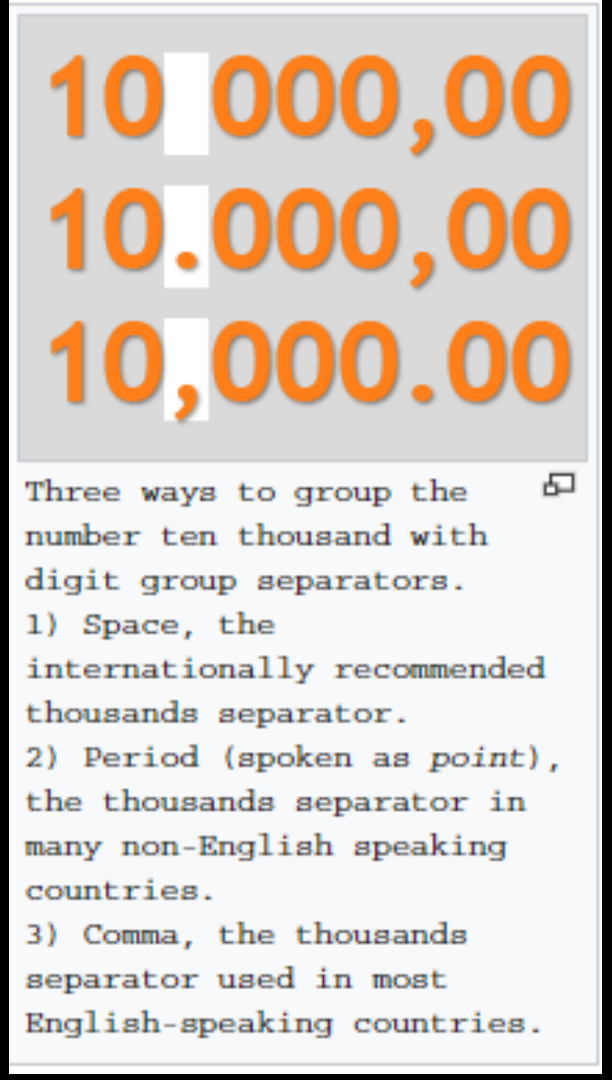
$$= \sqrt{\frac{2(1000)(6.67384 \times 10^{-11})}{6.370 \times 10^{6}}}$$

$$= 1.4475 \times 10^{-7} \, ms^{-1}$$

$$\approx 1.45 \times 10^{-7} \, ms^{-1} \quad (3 \text{ s.f.})$$

- Mass confusion: What units, how come this equation?





- Also your thousand separator: recommended to use space or standard form instead

Failure to read Small Print

- Question: [8]Held on the 15th day of the 8th month of the Chinese lunisolar calendar, when the Moon is brightest and at its full size.

3x 2	Mid-autumn is when the moon is at a waxing cresent, making the temperature cooler.

Cases of blatant copying

- We know this is an open book exam and that is why we require some thinking
- Especially when the question asks you to calculate but you decide to write an essay instead
- It can be quite obvious if you use Americanized units such as Pounds, Feet, Family cars and other such nonsense

(b) Calculate the amount of energy saved by launching a rocket eastwards into a circular orbit with altitude 1000 km from the surface exactly at the Earth's equator, as compared to launching the same rocket to the same altirude from the surface from the South Pole. For this question, you may assume that the Earth is a perfect sphere.

(b) The land at the equator is moving 1670 km per hour, and land halfway to the pole is only moving 1180 km per hour, so launching from the equator makes the spacecraft move almost 500 km/h faster once it is launched. At liftoff, the two Solid Rocket Boosters consume 11,000 pounds of fuel per second. That's two million times the rate at which fuel is burned by the average family car. The twin Solid Rocket Boosters generate a combined thrust of 5.3 million pounds. Also, Earth rotates eastward on its axis, one complete turn each day. At the equator, Earth's surface is rotating at 1675 kilometers per hour. So if we launch the rocket toward the east, it will get another big boost from Earth's rotational motion. One spot on the equator has to go a much greater distance than a spot near the poles, for instance. So a rocket launching on the equator gets an extra speed boost, making it easier for the vehicle to reach the extra high velocities needed to achive orbit. It's due the equator rotating faster so the spacecraft can move faster and use the natural speed as a boost and advantage to break through Earth's atmosphere by moving at a slower pace than needed because there is already the speed boost near the equator.

Google

rocket booster two million times

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At liftoff, the **two** Solid **Rocket Boosters** consume 11,000 pounds of fuel per second. That's **two million times** the rate at which fuel is burned by the average family car. The twin Solid **Rocket Boosters** generate a combined thrust of 5.3 **million** pounds.

www.nasa.gov › default › files PDF

Shuttle Trivia FS.indd - Nasa

About featured snippets Feedback

When the engines are fired, an unbalanced force accelerates the rockets out the sky. The upward force of the thrust from the rocket engines is greater than

Google

when the rockets are fired an unbalanced force

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About 1,660,000 results (0.54 seconds)

When the engines are **fired, an unbalanced force** accelerates the **rocket** into the sky. The upward **force** of the thrust from the **rocket** engines is greater than the downward weight of the **rocket**. This results in an **unbalanced** upward **force**, causing the **rocket** to accelerate upwards.

www.bbc.co.uk › bitesize › guides › revision

Using Newton's Laws effectively - Newton's Laws - National 5 ...

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www.grc.nasa.gov › www › rocket › TRCRocket › roc...

Rocket Principles - Nasa

In **rocket** flight, forces become balanced and unbalanced all the time. ... **unbalanced force**, such as friction with gas molecules in orbit or the **firing** of **a rocket** ...

Bad Handwriting + random ad libbed answers

3: When one body [illegible] a force on a second body, the second body simultaneously exerts an equal and opposite force on the first body. The rocket combusts fuel to expel gases from its thrusters, and the gases exerts a force on the surrounding atmosphere, causing the atmosphere to exerse an equal but opposite force on the rocket, propelling it upwards.

Since a rocket has to achieve a greater acceleration than the gravitational pull of earth at 9.81 m/s to reach escape velocity, for a greater magnitude of thrust, the rocket must have a payload limit to ensure that the force of the rocket thrusters can provide enough acceleration for the rocket to reach escape velocity.

(d) Estimate the flight time of the probe, from the time when it is with the LOP-G on the apolune of the LOP-G's orbit, to when it lands on the surface of the Moon. [2]

(e) By using conservation of energy, derive an expression for the speed of the probe at any distance r away from the center of the moon when it is in a lunar orbit with a semi-major axis of a. [3]

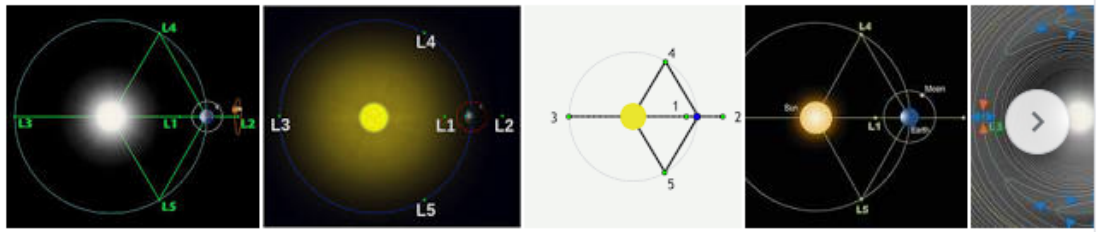
d) 4 days

e) $v = \frac{2\pi r}{\sqrt{a^3}}$

Other examples

- The Lagrangian Point question:

Many just copied wholesale!



A Lagrange point is a location in space where the combined gravitational forces of two large bodies, such as Earth and the sun or Earth and **the moon**, equal the centrifugal force felt by a much smaller third body. Aug 22, 2017

www.space.com › 30302-lagrange-points

Lagrange Points: Parking Places in Space | Space

Lagrange point

From Wikipedia, the free encyclopedia

For the video game, see Lagrange Point (video game).

In celestial mechanics, the **Lagrange points** /lə'grɑːndʒ/ (also **Lagrangian points**, **L-points**, or **libration points**) are orbital points near two large co-orbiting bodies. At the Lagrange points the gravitational forces of the two large bodies cancel out in such a way that a small object placed in orbit there is in equilibrium in at least two directions relative to the center of mass of the large bodies.

There are five such points, labeled L_1 to L_5, all in the orbital plane of the two large bodies, for each given combination of two orbital bodies. For instance, there are five Lagrangian points L_1 to L_5 for the Sun–Earth system, and in a similar way there are five *different* Lagrangian points for the Earth–Moon system. L_1, L_2, and L_3 are on the line through the centers of the two large bodies, while L_4 and L_5 each act as the third vertex of an equilateral triangle formed with the centers of the two large bodies. L_4 and L_5 are stable, which implies that objects can orbit around them in a rotating coordinate system tied to the two large bodies.

Consider this

- If we wanted you to copy wholesale without thinking, we would have just done it ourselves

- Why would we want to award marks for ability to copy?

Positive example from your peers

j) In the rotating frame where the ~~sun~~ moon and earth are stationary, ~~the~~ ~~the~~ a satellite at one of the lagrange points will also be stationary.

Part 3(j)] langarian points are points that are gravitationally stable.

(j) A Lagrangian point is a position in space where the gravitational pull of two large masses precisely equals to the centripetal force required for a small object to move with them.

Junior DRQ 3

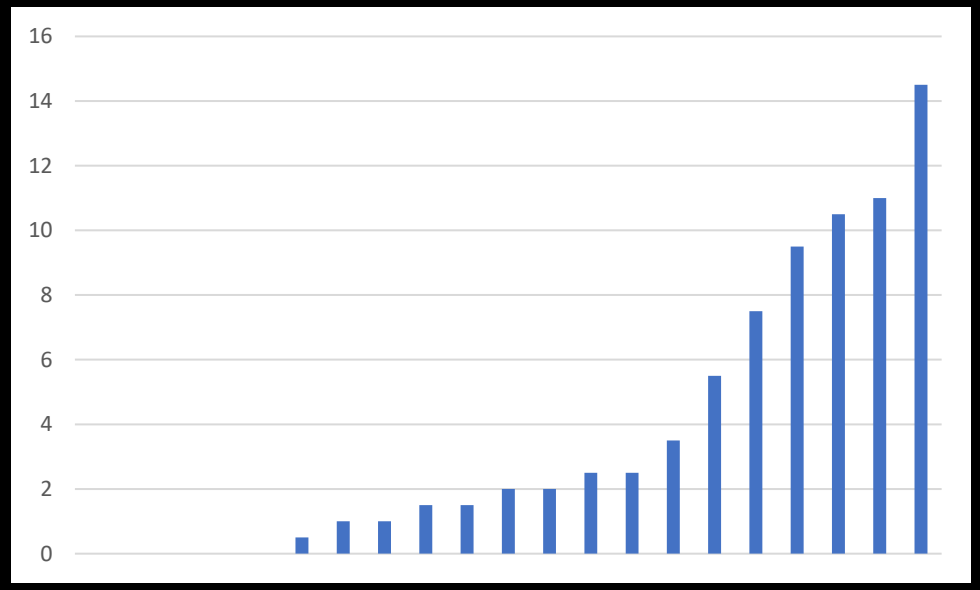
Bloom and Boom

Camille

Unless otherwise stated, all images in this section that are NOT of scripts are taken from Google search.
Credits: Akagami no Shirayuki-hime, Kyoukai no Kanata, Ansatsu Kyoushitsu, Kono Subarashii Sekai ni Shukufuku o!, Kanata no Astra, Fate/Grand Order, K-ON!

JNR DRQ3: Bloom and Boom

- Idea behind the question:
  - Investigate ‘life and death’ in the universe
  - Was meant to be a mostly easy question over a few topics!
- Fun fact:
  - Question was made after watching two anime:
    - One romance with lots of flowers
    - One sci-fi involving visiting various planets with life after being trapped in deep space



- Mean: 3.64
- Median: 2
- Mode: 0

Part I: The Biggest B(l)oom

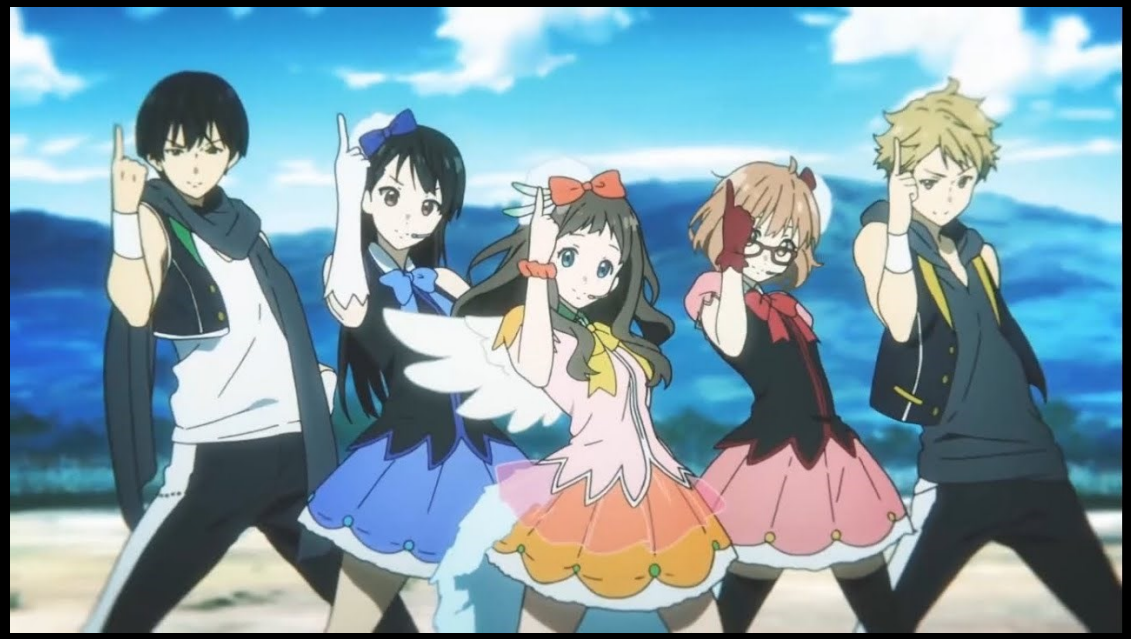
- A simple question about the Big Bang.
- It became a Google copy-fest!
- What you did right:
  - …
- What you did wrong:
  - I can Google your answers!
  - And they're word-for-word!

The Four Pillars – An Overview

- Expansion of the Universe
  - Linked to origination from a single point
- Cosmic Microwave Background Radiation
  - Linked to recombination epoch and transparency to radiation
- Nucleosynthesis of light elements
  - Is in good agreement to proportion of light elements today
- Formation of galaxies and large-scale structure of the Universe
  - Linked to gravitational dominance as energy density composition shifted towards matter

Part II: Blooming Stars

- Variable stars time!
- Focuses on Cepheid variables
- What you did right:
  - ……
- What you did wrong:
  - I can ALSO Google your answers!
  - And they're ALSO word-for-word!

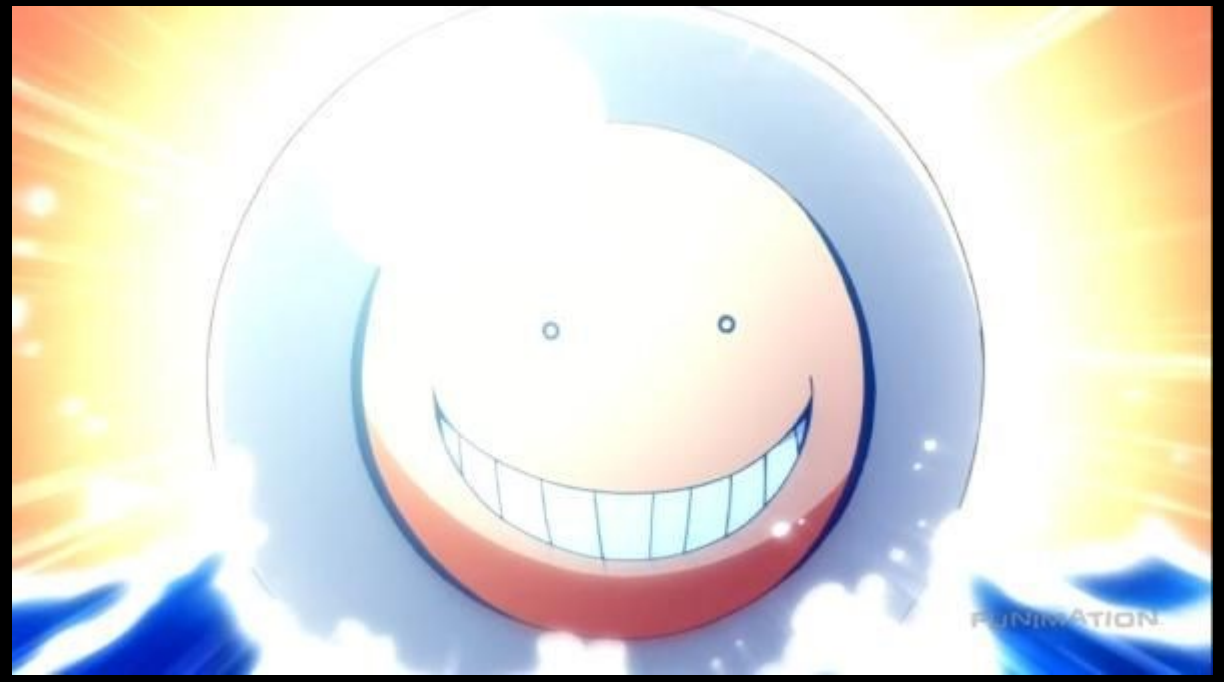


*Not the correct type of blooming stars.

Kappa Mechanism

- Responsible for change in brightness of Cepheid variables

- Mediated by ionised helium shell
  - 2+ ionisation more opaque, causing *dimming* and expansion. Shell temperature falls, 1+ ionisation favoured.
  - 1+ ionisation less opaque, causing *brightening* and shrinking! Shell temperature rises, 2+ ionisation favoured.
  - This works in a cycle!



Part III: Booming Stars

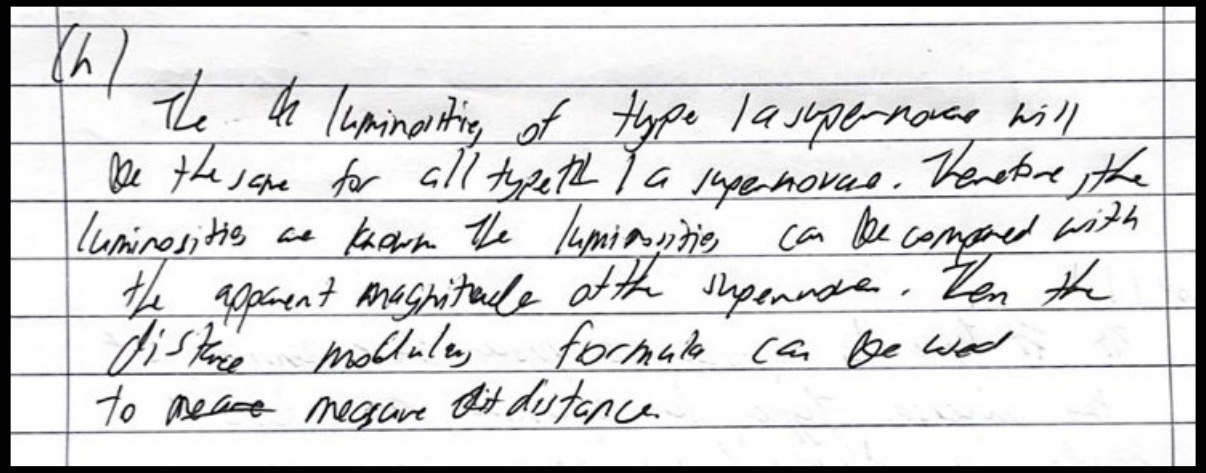
- Planetary nebulae and type Ia supernovae!
- Focuses more on nebulae, though.
- What you did right:
  - ……
- What you did wrong:
  - Guess what I can do?
  - It has three words, starts with ‘G’, and ends with ‘s’.

Planetary ~~Supernova~~ Nebula

- Planetary nebulae and type Ia supernovae
  - Are NOT the same thing!

- Planetary nebulae:
  - Shells of ionised gas ejected from red giant stars in late life!

- Type Ia supernovae:
  - Forms in binary systems, one star being a white dwarf!


(h)
The ~~th~~ luminosities of type Ia supernovae will be the same for all type Ia supernovae. Therefore, the luminosities are known the luminosities can be compared with the apparent magnitude of the supernovae. Then the distance modulus formula can be used to ~~measure~~ measure the distance.

NOT how you measure distances to nearby planetary nebulae!

Part IV: B(l)oom Into You

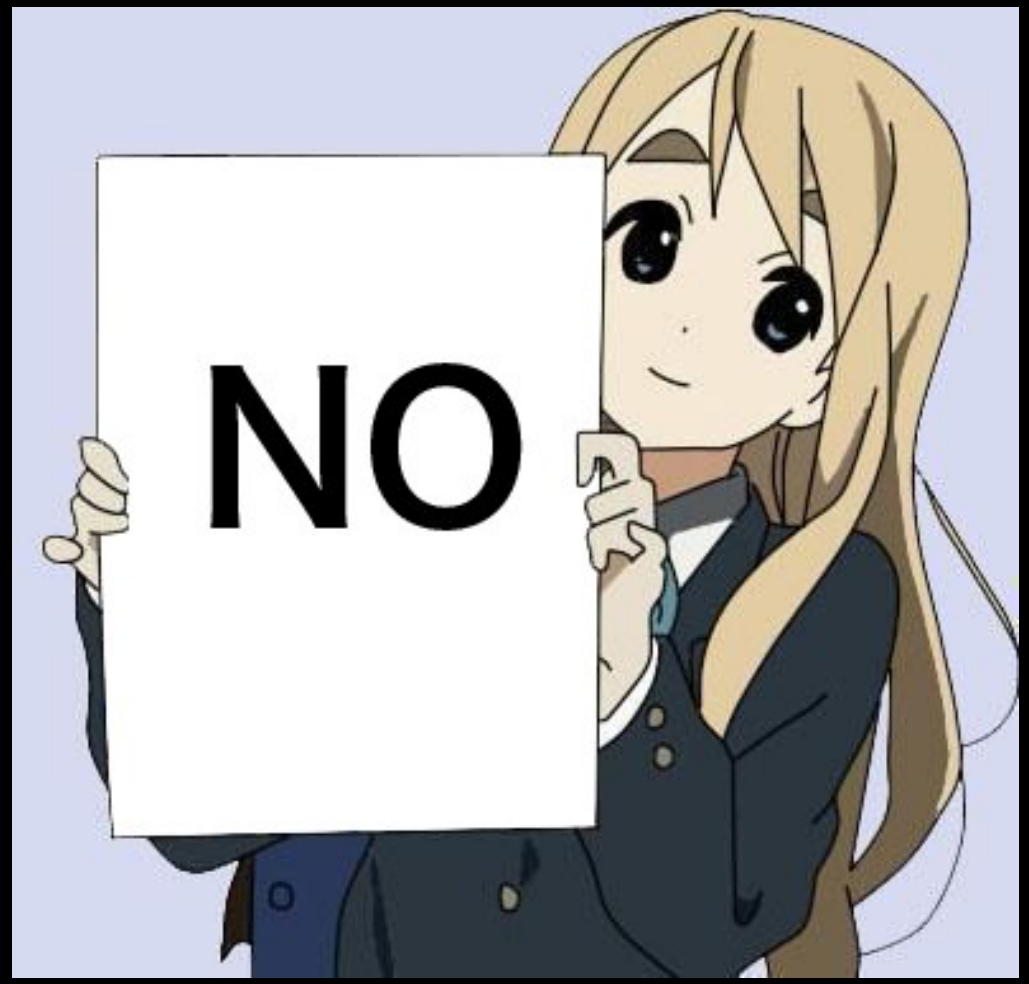
- An introduction to the CHZ.
- Important concept in finding extra-terrestrial life!
- What you did right:
  - Recognised limitations of CHZ.
- What you did wrong:
  - Didn’t explain the limitations.
  - Do I even need to say what else at this point?

Circumstellar Habitable Zone

- What it does:
  - Crude search for possibility of water.
  - Accounts for orbital distance primarily.
- Why water?
  - Earth-like biosphere depends on water!
  - The only known biosphere.
- What it *doesn't* do (a sample):
  - Consider alternate biologies.
  - Consider stellar activity.
  - Consider subterranean oceans.
  - Consider radiation and/or atmospheric composition/opacity.
  - Consider planetary composition.
  - …and so on!

Special Edition: Label your answers correctly!

- DON’T write an answer to Question 2 as Question 1!
- DON’T write an answer to Part (b) as Part (c)!



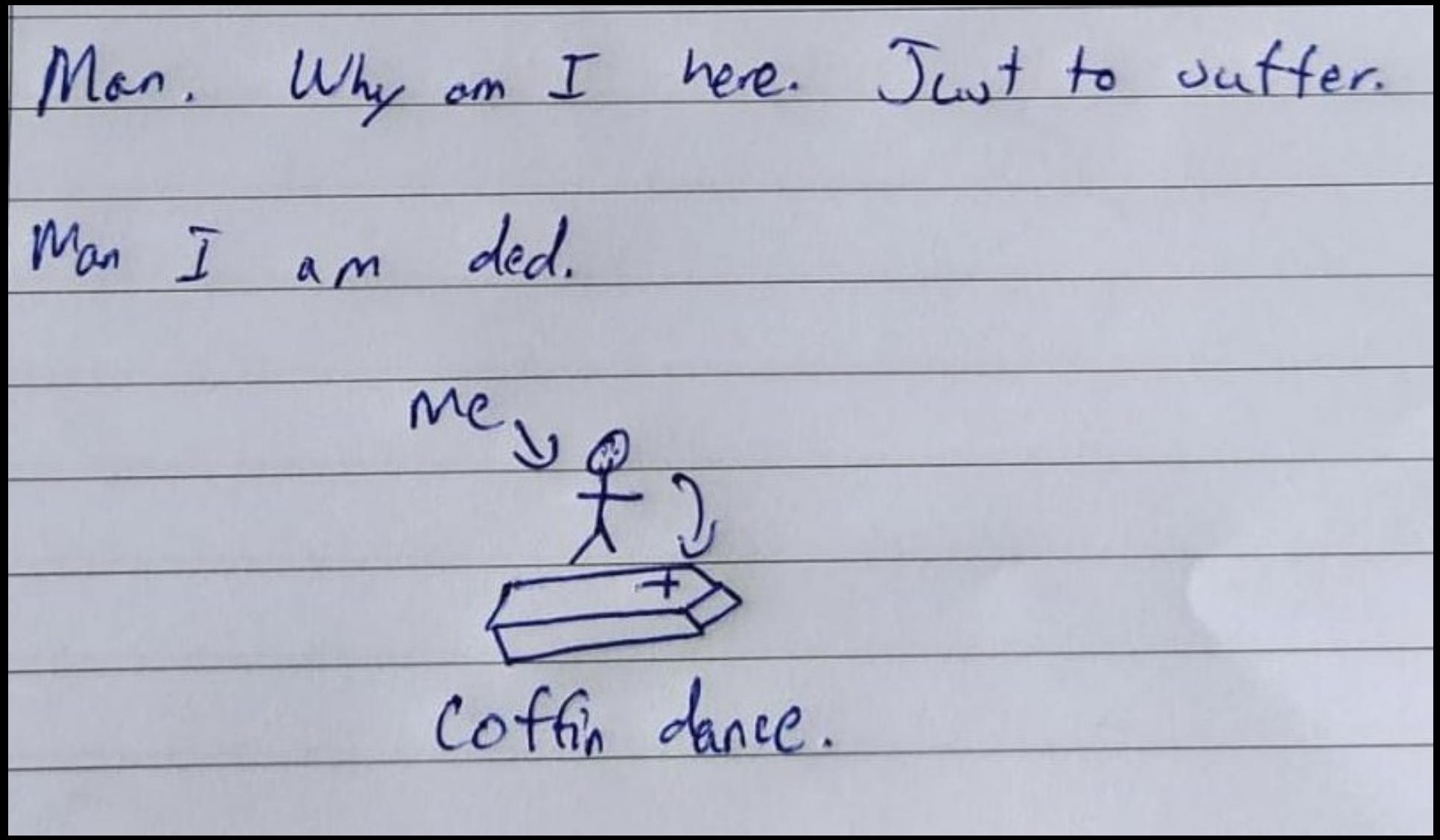
Special Edition: Google and You

- It is *okay* to Google things you don't know.
  - In fact, that's how you learn many new things!

- It is *not okay* to copy everything wholesale from Google!
  - Information online can be <u>inaccurate</u> or <u>incomplete</u>.
  - Copying others' work without due credit is considered plagiarism!
  - Sometimes, it doesn't answer the question!

- You should…
  - Use Google as a very abundant *source* of information.
  - Extract only the relevant pieces of information, form them into a cohesive whole, and then *create* an answer!

When You Give Up, Coffin Edition:



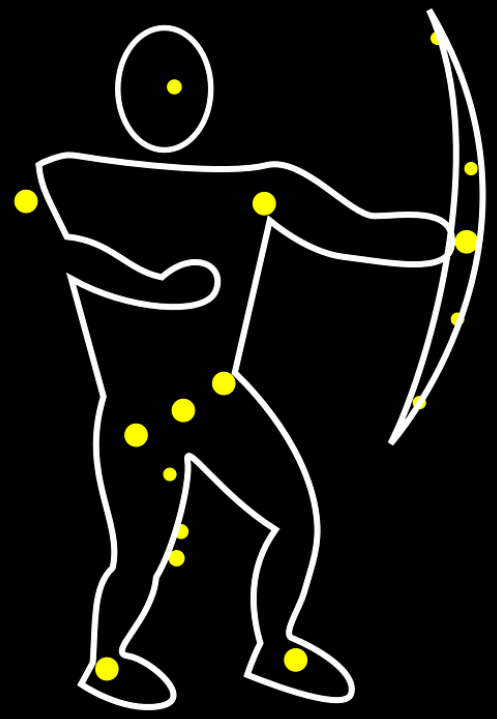
JNR DRQ 4

Hero among the constellations – Orion

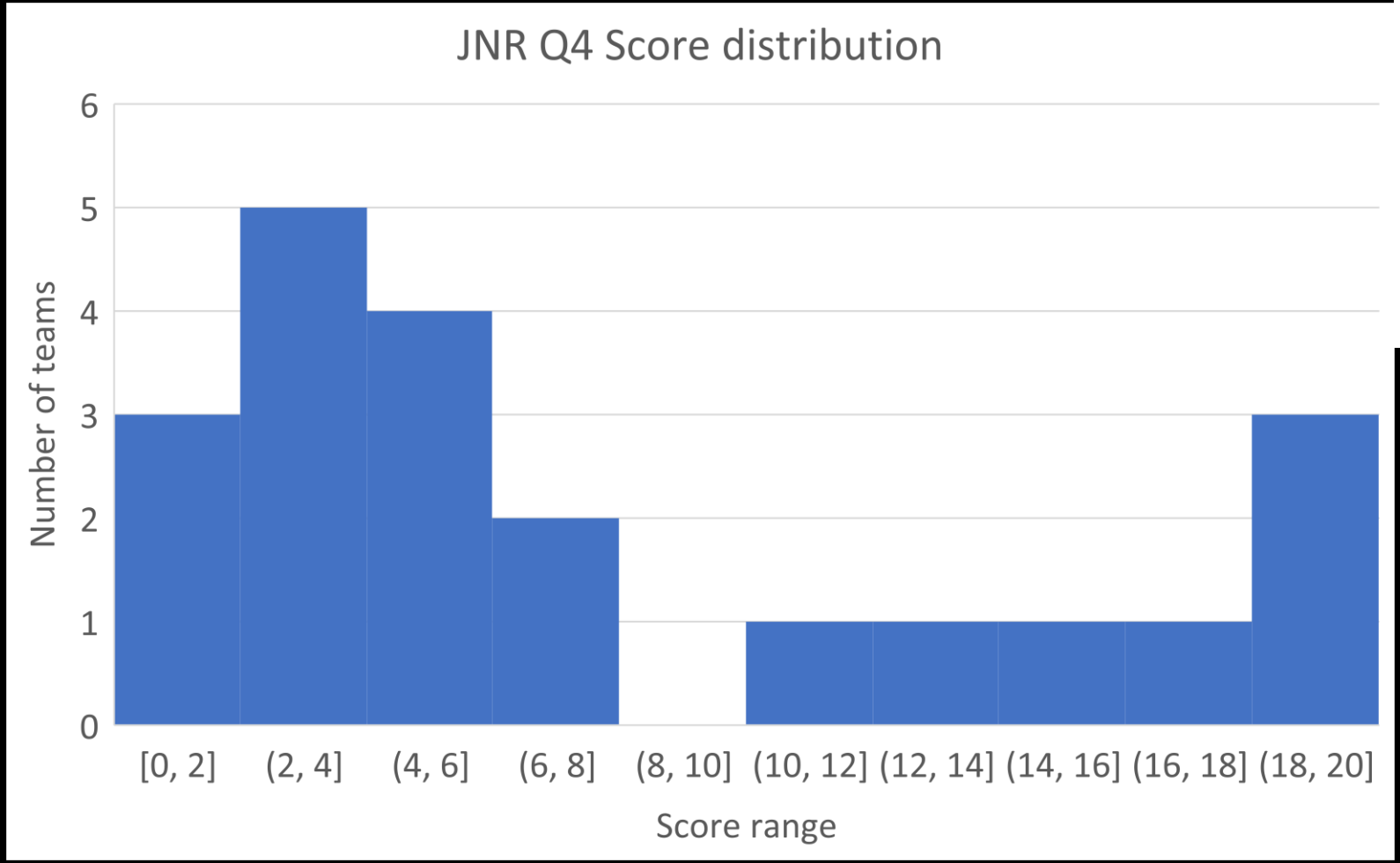
Qi En

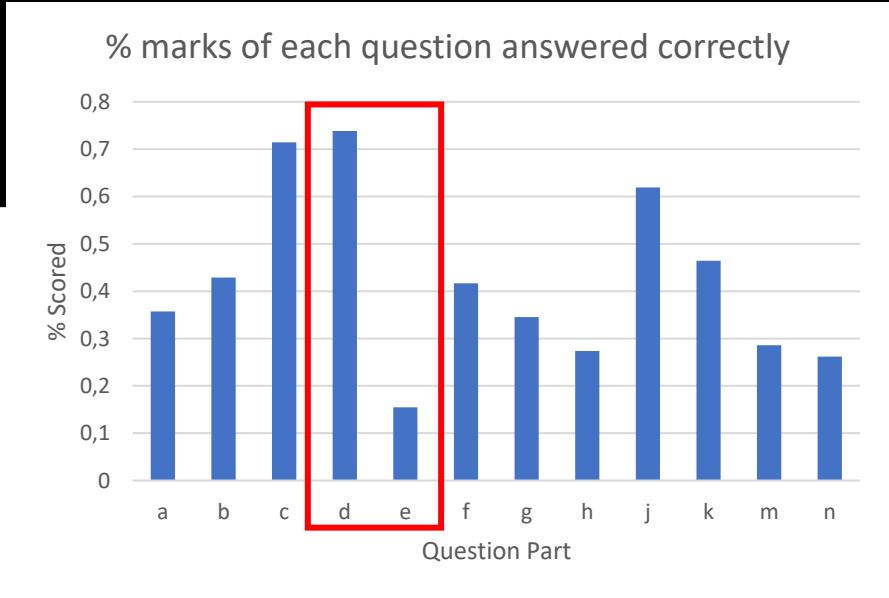
Expectation:

Reality:



Stats for Question 4:





Average	7.98
Median	5.5
Standard dev	±6.25

Overall comments

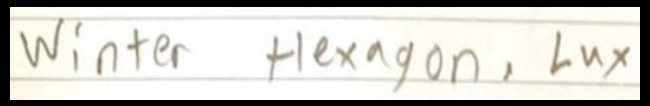
- Despite the abysmal performance, it was the second easiest question for Junior Team round
- Most schools that did badly either wasted too much time on math (only one part submitted) or could not do the math at all
- Fairly straightforward question that mostly tests the team's ability to perform simple calculations, interspersed with conceptual or factual questions ranging from challenging to easy in an open book setting

"Orion's Belt is a big waist of space."

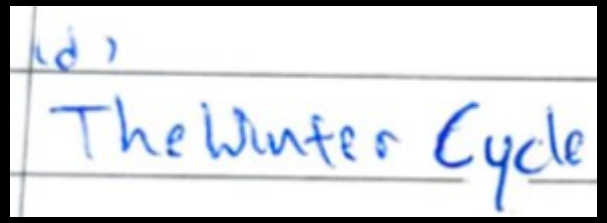
Terrible joke. Only three stars.

Most easy question: Act II part (d)

- Which famous Asterism is Rigel in? Name one other star in the same Asterism. (2m)
  - Literally meant to be a FREE GIVEAWAY in Open book! You literally could just copy three words from Google and I cannot fault you for doing so!
  - Some teams could still get it wrong…



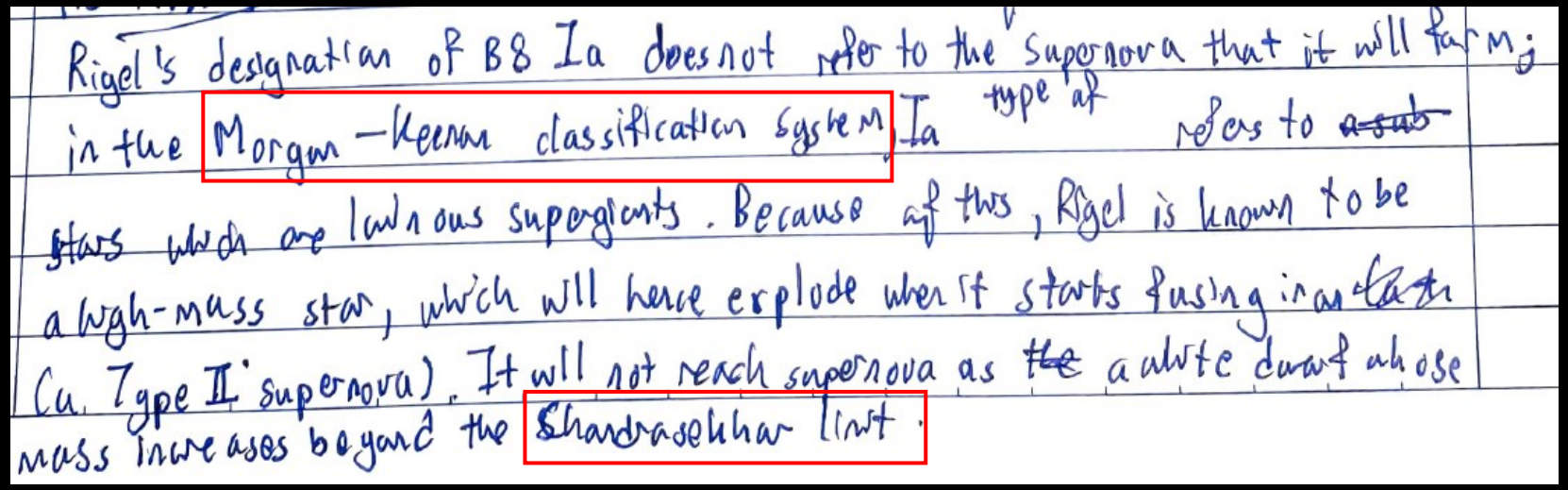
This mistake has been certified UNSTOPPABLE



(For context: Winter Hexagon and Winter Circle is accepted)

Most difficult question: Act II part (e)

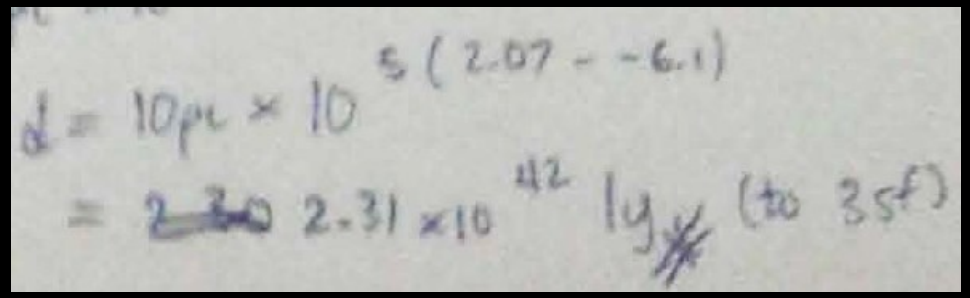
- A student new to astronomy saw Rigel's designation as a B8 Ia star. However, Rigel will end its life cycle as a Type II supernova, not a Type Ia supernova. Explain briefly why this is the case. (2m)
  - Question worked as intended to be Google-proof; it is a higher-level conceptual question. Plenty of answers were at best grossly incomplete or at worse outright 'smoking'
  - Model answer e.g.



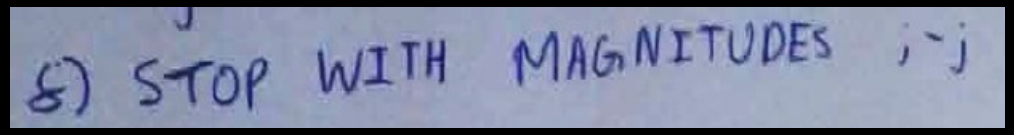
Rigel's designation of B8 Ia does not refer to the supernova that it will form; in the Morgan-Keenan classification system, Ia type of refers to ~~a sub~~ stars which are luminous supergiants. Because of this, Rigel is known to be a high-mass star, which will hence explode when it starts fusing iron (i.e. Type II supernova). It will not reach supernova as ~~the~~ a white dwarf whose mass increases beyond the Chandrasekhar limit.

Other things to take note:

- For section g, question asks for Surface Temperature, not Luminosity
- PLEASE WRITE **UNITS,** ELSE ITS 0 FOR ANSWER MARKS
- Please check if your answer makes sense given units!

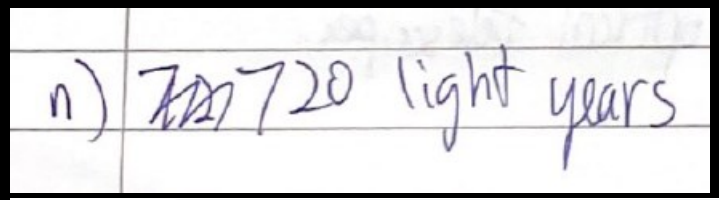


Size of the observable universe: ~9.3 × 10^{10} light years

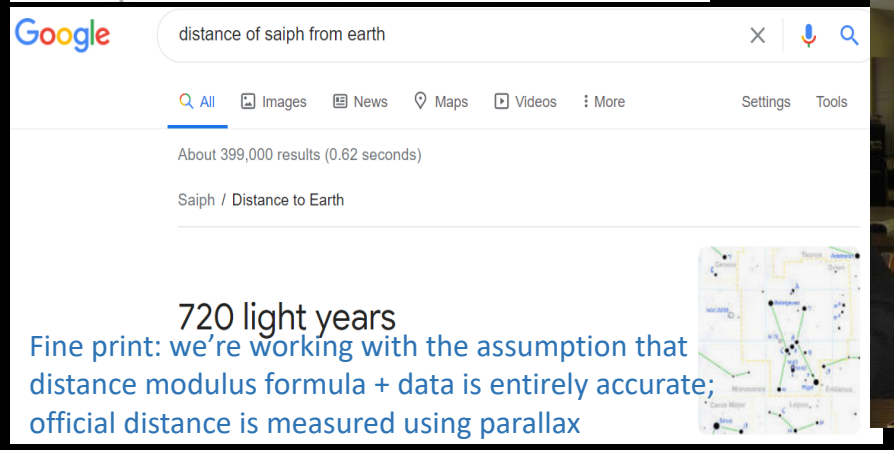


(Get better at Astro and try again next time! Magnitude questions are easy once you catch the drift.)

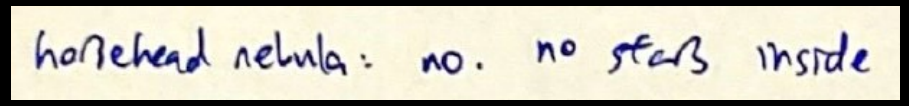
Other honourable mentions (self-explanatory)

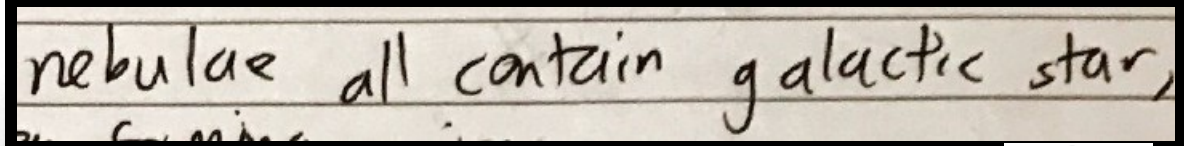


Answer if you used Distance Modulus: ~1400 ly (2 s.f.)



Fine print: we're working with the assumption that distance modulus formula + data is entirely accurate; official distance is measured using parallax





(Time traveller from Hubble's period where all galaxies are nebulae???)

JNR DRQ 5

Brian Arcillas

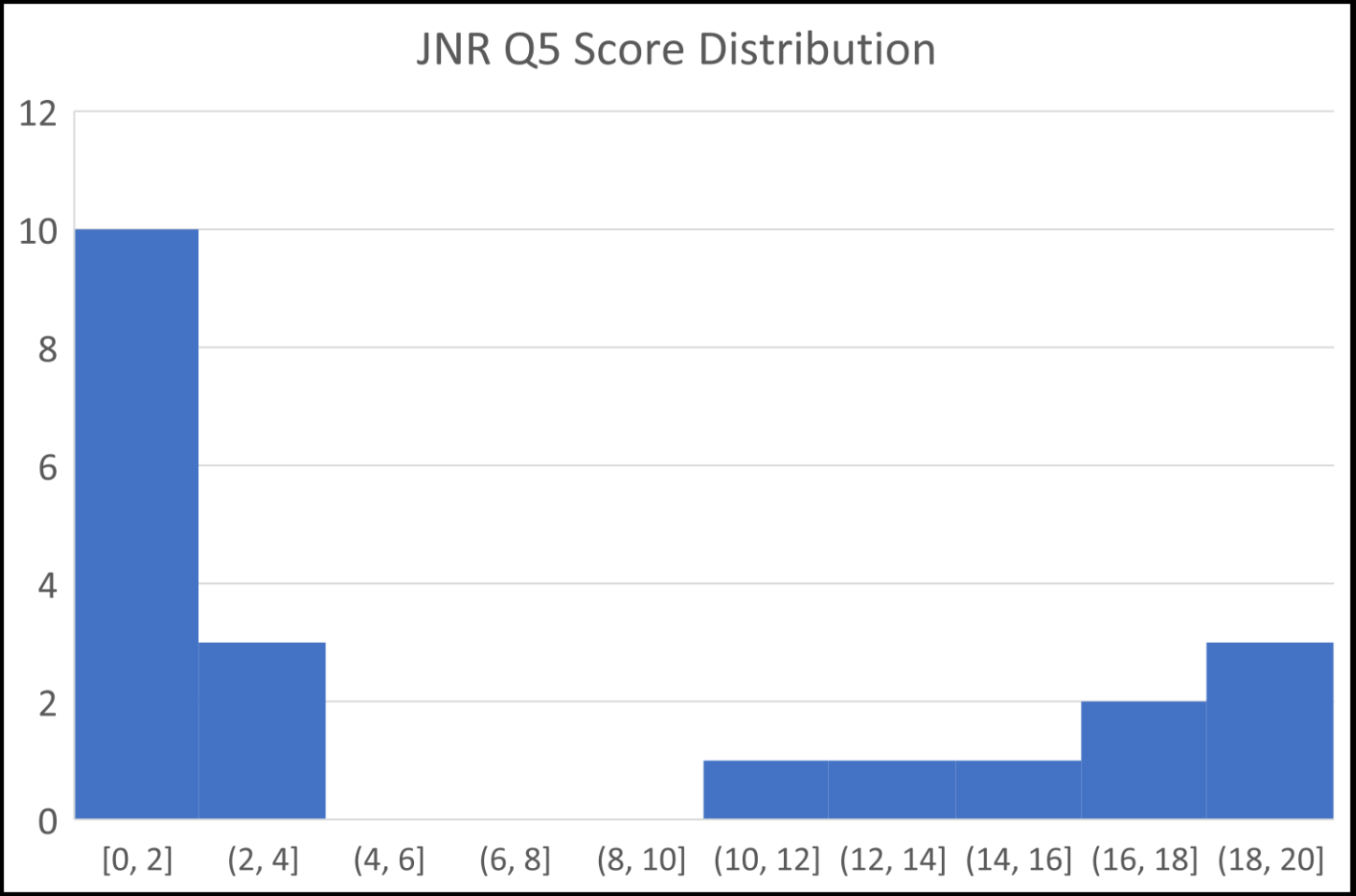
General Comments

- This question was intended to be an giveaway, especially since it was open book.
  - See answer scheme for details
  - For those who did not know about the night sky – this was an opportunity to learn about it (with the self-penalty of time that could be spent elsewhere in the Team Round)
  - Most who attempted the question got very high marks

- Unfortunately, due to poor time management, many did not attempt this question <u>at all</u>.

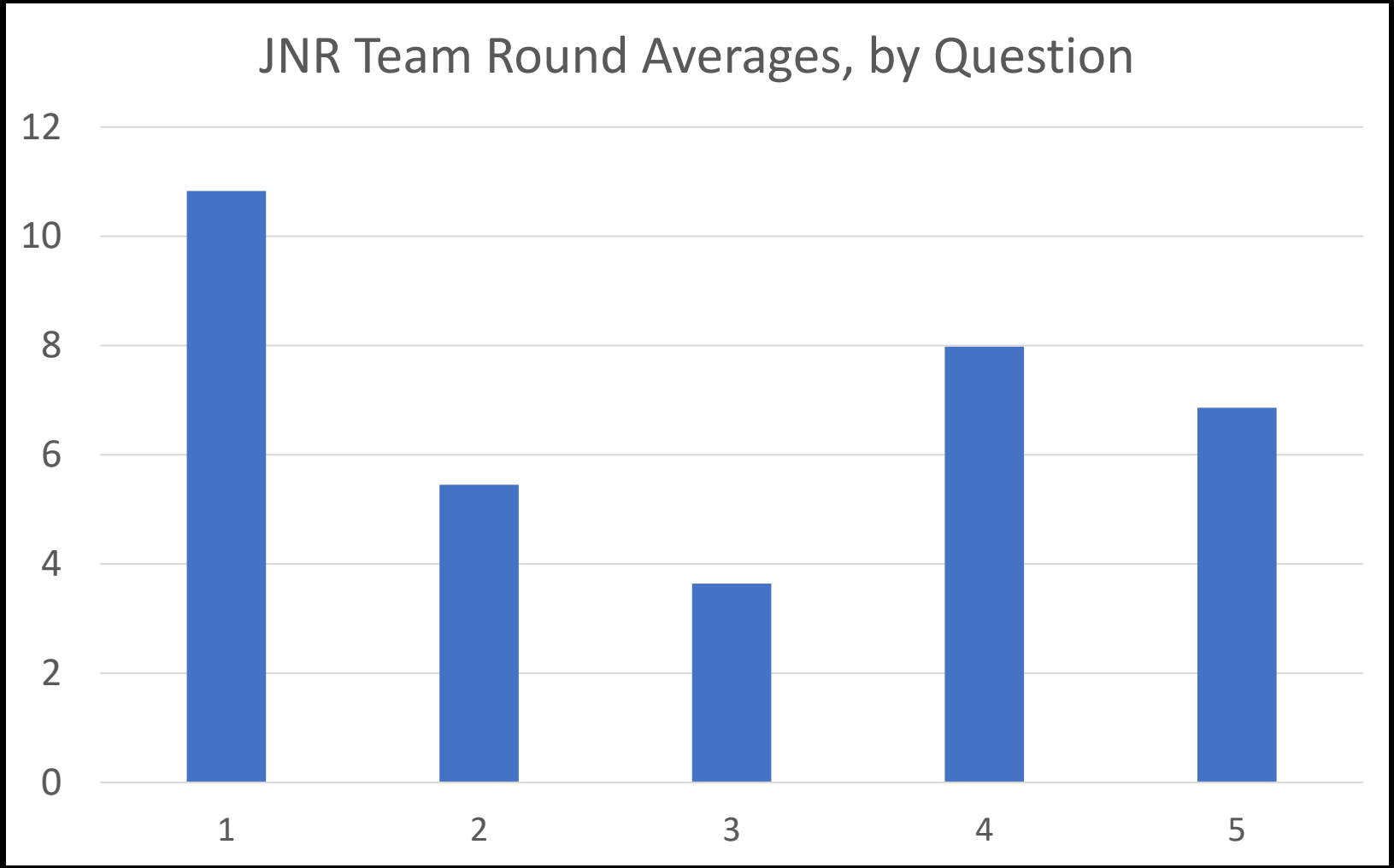
Poor time management kills!

- Average among all teams = 6.9
- Average among all teams that had a non-zero score = **<u>12</u>**



Team Round
Summary Statistics

Team Round Question Averages



Team Round Overall Statistics

- Mean: 34.6
- Median: 27.5
- Std. Deviation: 22.35