AstroChallenge 2024
Theory Observation (Team A) Round

Monday 3rd June 2024

PLEASE READ THESE INSTRUCTIONS CAREFULLY.

1. This paper consists of **10** printed pages, including this cover page.
2. Do **NOT** turn over this page until instructed to do so.
3. You have **1.5 hours** to attempt **ALL** questions in this paper.
4. The marks for each question are given in brackets in the right margin, like such: **[2]**.
5. The **alphabetical** parts (i) and (l) have been intentionally skipped, to avoid confusion with the Roman numeral (i).
6. Ensure that your school and team number are clearly on the cover of this booklet.

School and Team Number	
Team Member 1	
Team Member 2	
Team Member 3	

Section A Celestial Valentine

This section contains two (2) tasks. Task 1 requires you to draw a finder chart for use by Team B, while Task 2 requires you to use the software Stellarium to follow the instructions on the finder chart drawn by Team B. You have a maximum of 20 minutes to attempt Task 1. You will need to hand in your Task 1 by the end of 20 minutes. After which, you can attempt Task 2 whenever you wish to, throughout the rest of the duration of the paper.

Background

It is the year 2069 and humans have colonised planet Mars and established a colony base on where it used to be called "Utopia Planitia". Elon Musk, as remembered by those born in the early 21st century, is now seen as a legendary figure who inspired the entire human race on their adventure into deep space and the development of the reusable what was once called the "Big Falcon Rocket".

Samantha and Walter knew each other since young. Having a degree in astronomy and hence being selected as a critical part in the colony base maintenance team, Samantha has the privilege to work on the Mars colony base and has access to the base's telescope stock during her free time. Walter, under the influence of his partner, had become an astronomy enthusiast and owns a collection of telescopes and accessories. On the last day of 2069, the couple wanted to look at each other through their own telescopes.

Task 1 (15 marks)

Your team will be helping with Walter in guiding him in finding Mars. Walter used Aldebaran to adjust his telescope set-up and hence this is where his telescope is currently pointing at. Draw a finder chart with the appropriate instructions in helping him star-hopping to Mars.

Figure 1 on the next page shows the screenshot on the software Stellarium, that indicates the sky Walter will be looking at. You should use it as a reference when drawing your star chart. Each box on Figure 1 represents **5 degrees** on the altitude-azimuth coordinate system.

You have access to the following equipment:

- 50 mm finder (5.5° FOV; 5× magnification)
- Newtonian reflector (125 mm diameter; 600 mm focal length) on an altitude-azimuth mount
- Eyepieces: 4 mm (50°), 15 mm (58°) and 25 mm (44°)

On your finderchart, you should include the following:

- The choice of equipment and accessories that you want Walter to use. You may ask him to switch between the different accessories that is available to him.
- Calculate/state the field of view for the combination of equipment and accessories you wish Walter to use.
- Brief explanation on how Walter can be sure that he has found Mars (end point). You may use any sketch/labelling in aiding your explanation.
- Any instructions that Walter should follow. It is advisable to use sketches extensively in giving the instructions.
- You are advised against instructing Walter to slew to his end target in one step only. Some information about the sky between his starting and ending points would be required.

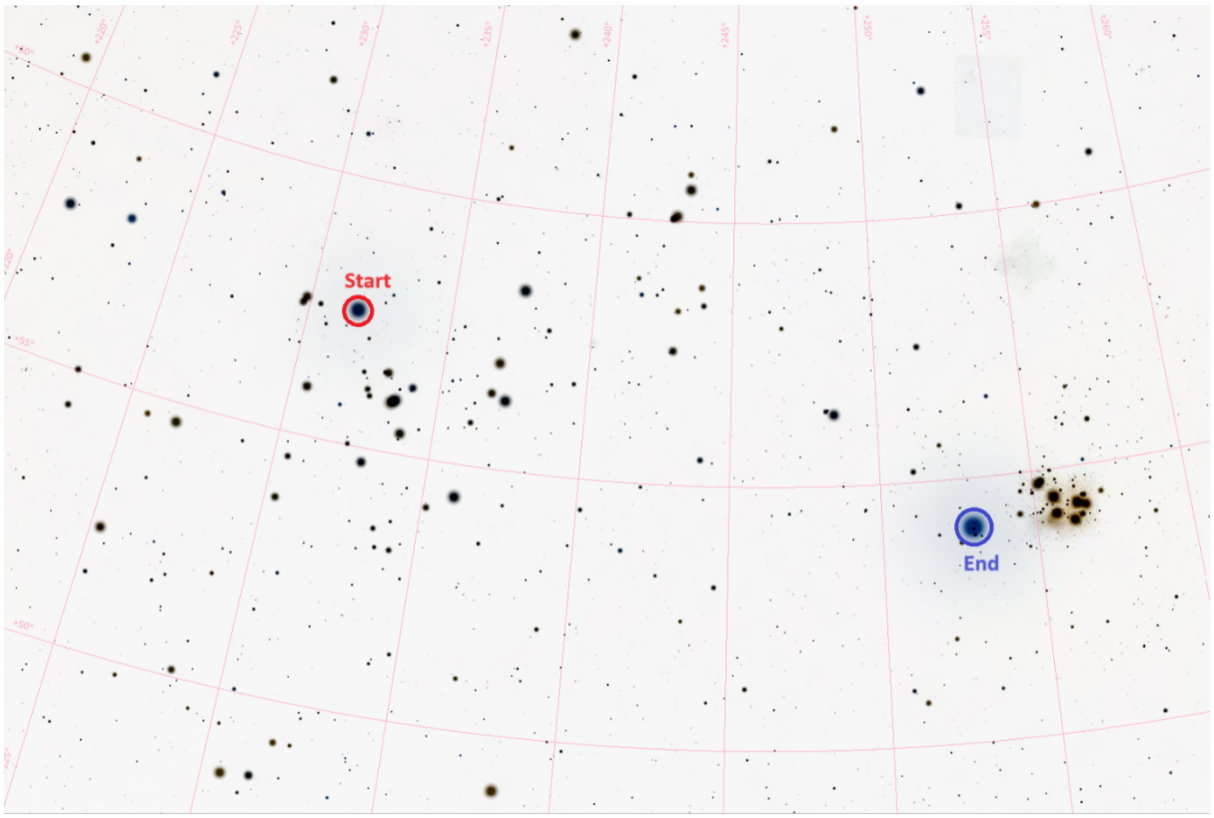


Figure 1: Walter's sky

Task 2 (5 marks)

Your team will now use the software Stellarium, that is positioned at exactly where Samantha is, to find Walter using the instruction sent to you from the other team.

You have access to the following equipment:

- 50 mm finder (5.5° FOV; 5× magnification)
- Newtonian reflector (125 mm diameter; 600 mm focal length) on an altitude-azimuth mount
- Eyepieces: 4 mm (50°), 15 mm (58°) and 25 mm (44°)

You have 10 minutes to attempt this task. You may only use the arrow keys to slew the telescope and request to change the accessories you are using. You may ask the facilitator to re-set your telescope to the starting position a maximum of two (2) times during the 10 minutes. The time it takes for facilitator to do so would be included in the 10 minutes you have (i.e., time would not be paused).

A successful attempt includes you identifying the correct end point to the invigilator. You will only be allowed **one** chance to do so.

Partial credit will be awarded if you have pointed out the wrong end point, but the actual end point can be seen in the final FOV after facilitator centres the FOV on the object you have pointed out, **without** changing the equipment configuration you last used.

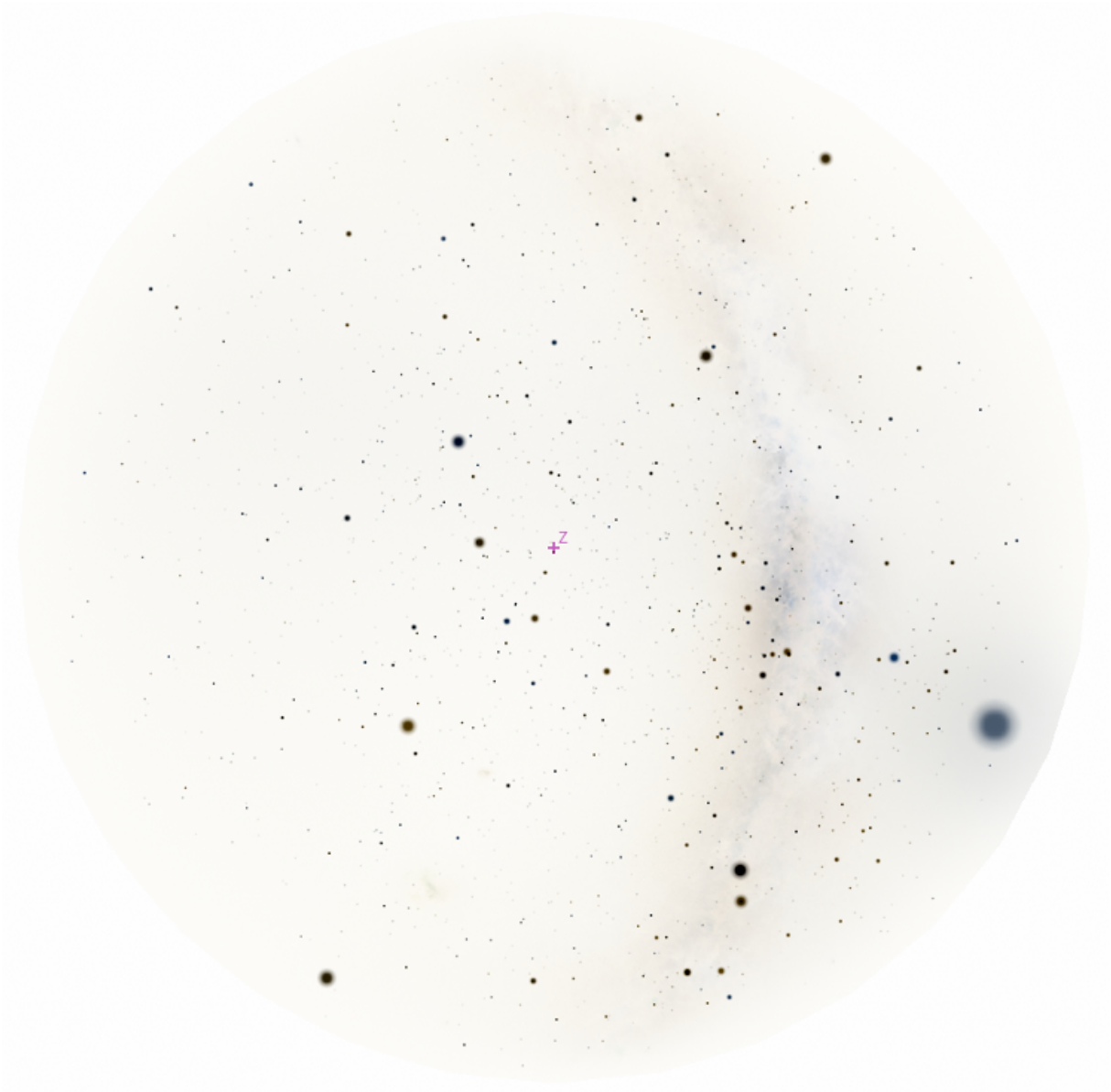
You are strongly advised to point out an endpoint.

Section B The Night Sky

You and your friends are on an overseas stargazing trip to Perth, Australia jointly organised by NUSAS and NTUAS. On the first night, the observation head of both clubs decided to conduct a night sky talk and jointly decided to quiz the participants on their knowledge on stargazing.

As ardent astronomers, you and your friends were determined to answer all the questions that they would quiz.

This is a stereographic projection of the sky on the night of the trip. The zenith point is marked with a pink cross and labelled for you as Z. Answer the questions in the space provided, or if so instructed, on the starchart on this page.



Hello everyone, welcome to the countryside of Perth Australia! As you can see, the night sky here at the countryside is much clearer than in Singapore thanks to a lower level of light pollution.

The first thing we astronomers always need to do is to find the cardinal directions. We can find the South celestial pole in this case by drawing two particular lines.

Does anyone in the crowd know how to do it?

(a) Using this information or otherwise, on the starchart, label the south celestial pole (SCP), clearly indicate your methods of locating it. [2]

Next, we would need to be able to find the local meridian and prime vertical. Would anyone like to give it a try?

(b) Trace out and label the local meridian (LM) and prime vertical (PV) on the starchart. [1]

Let's see... What can we say about the cardinal directions?

(c) Label the cardinal directions on the starchart. [1]

As you can see, the moon is ***A*** *just above the* ***B*** *horizon. The time now is* 9 pm *local time, and since the moon is at the* ***B*** *horizon, the phase of the moon is* ***C****.*

You missed the important information that the club observation head presented. However, you were determined to figure out yourself.

(d) Circle the most appropriate answer for A and B. [2]
For C, fill in the blank and draw a diagram below to explain your answer. [2]

A: rising/setting

B: eastern/western

C:

You can visibly see the milky way tonight! The brightest part of the milky way occurs near the constellation Sagittarius, part of which forms the asterism teapot.

(e) Where is the teapot? Trace out and label on the starchart. [1]

This direction in the sky is towards the centre of the milky way, and hence we are able to see many Deep Sky Objects (DSOs)

Deep Sky Objects are objects that are not individual stars or solar systems objects. There are mainly three broad types of DSOs, namely star clusters, nebulae and galaxies.

(f) Label and circle 1 of each type on the starchart. [3]

*Star clusters are also classified into globular and open clusters, while nebulae are classified as diffuse nebulae, planetary nebulae, and supernova remnant. Both supernova remnant and planetary nebulae are formed as the result of the death of a star. The reason why some stars form supernova remnant and others form planetary nebula, while others may even form black holes upon their death is the differences in their **D**.*

(g) Oh no, you missed the important information again. What is D supposed to be? [1]

D: .....

*Constellations are areas on the celestial sphere in which a group of visible stars forms a perceived pattern or outline, typically with mythological association. The International Astronomical Union (IAU) recognises **E** constellations, together covering the entire celestial sphere.*

(h) E is the total number of IAU recognised constellations. What is E? [1]

E: .....

There are many constellations visible in the night sky tonight!

(i) On the starchart, trace out and label at least 3 other complete constellations. [3]

[Note: Marks will not be awardede for tracing and labelling of Sagittarius, Crux or Ophiuchus. Marks will only be awarded for the correct tracing and labelling of any other constellations.]

Asterisms are observed patterns or groups of stars in the sky. It is a more general concept than the constellations formally recognised by the IAU. There are a few other prominent asterisms in the night sky tonight, namely the summer triangle and the great square of Pegasus. Does anyone know where they are?

(j) On the starchart, trace and label the great square of Pegasus and the summer triangle. [2]
Name and label the vertices of the summer triangle as well. [1.5]

Apart from the moon, there is another solar system object in the night sky tonight! Would anyone like to point it out?

(k) Circle it out on the starchart and label as "*P*". [1]

[Note: Marks will not be awarded for labelling the Earth.]

The ecliptic is the apparent path of the sun on the celestial sphere. We can therefore estimate the rough direction of the ecliptic. Would anyone give it a shot?

(l) Assume that both the Saturn and the Moon are very near the ecliptic today, on the starchart, sketch out the ecliptic. [1]

(m) Briefly explain why is this only an estimate of where the ecliptic actually is? Would any of the above assumptions be not valid on certain days? You may consider alternative perspective of the definition of the ecliptic. [1.5]

Everyone has probably heard about the 12 zodiac signs in astrology. They correspond to 12 zodiac constellations in the night sky, all of which lie along the ecliptic. However, the effect of axial precession of the Earth, over thousands of years, has changed the apparent path of the sun on the celestial sphere. Some now say that a 13th constellation, namely Ophiuchus, should also be included in the zodiac as it lies along the ecliptic. Does anyone know where Ophiuchus is?

(n) On the starchart, trace out and label Ophiuchus. [1]

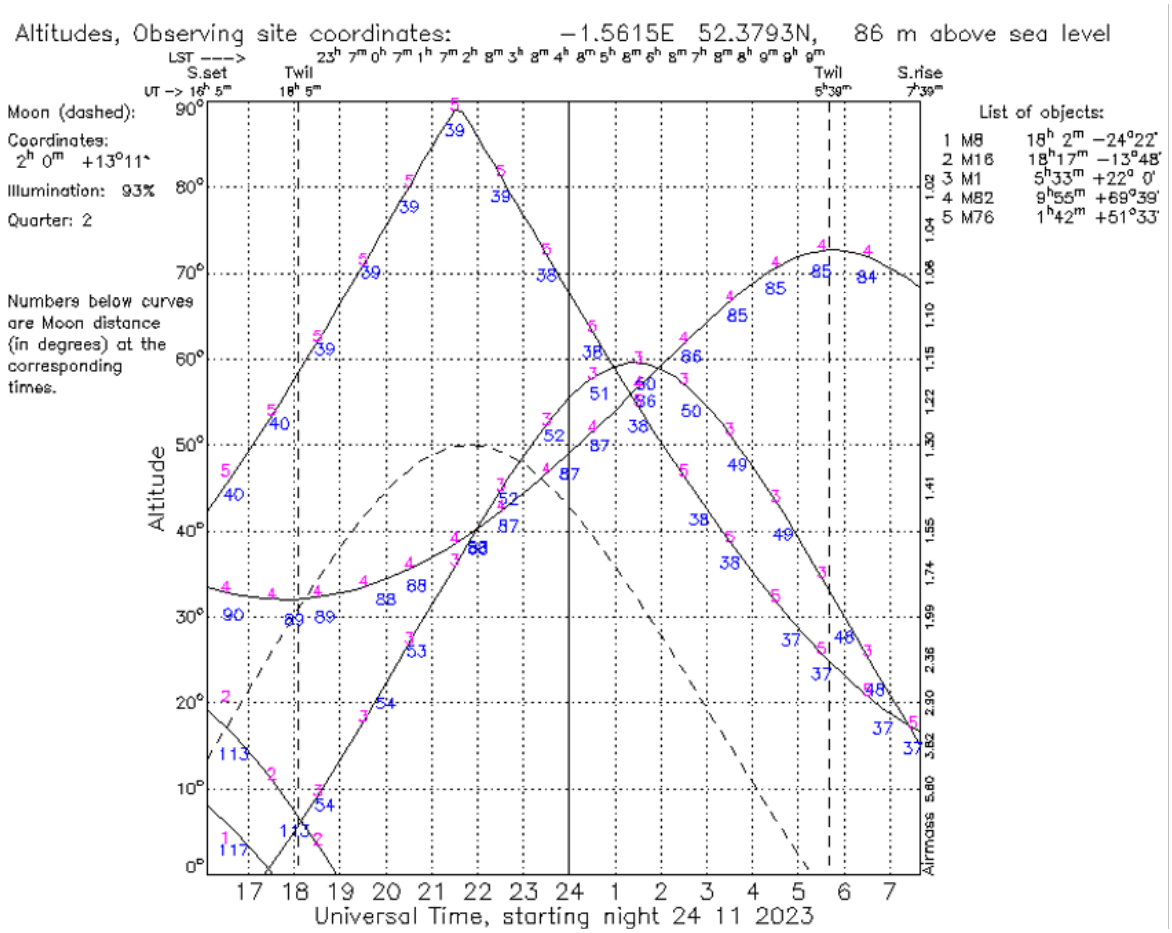
Axial precession is the reason some are proposing a change in the date of zodiac signs. As the dates were originally meant to indicate the days when the sun is in that constellation, the effect of precession has made the dates not indicative of the position of the sun. Hence, some propose a new zodiac with 13 signs, including Ophiuchus, with revised dates such that they indicate the dates when the sun is inside the constellation. However, it has not been adopted as people prefer to continue to subscribe to the original 12 zodiac signs.

Thank you everyone for listening in to my night sky talk. Hope that you have learnt something new today and enjoy the night sky away from the buzzling city state of Singapore!

Section C Observatory Experience

The graph below shows the altitudes, above horizon, of 5 deep sky objects (DSOs): M8, M16, M1, M82, M76, plotted against time. The date is 24 November 2023, the sun sets at 4.05 pm and it gets completely dark at 6.05 pm.

The number above each line refers to the object the line is for. Please refer to the "List of objects" **on the right** for the DSO that each number refer to. The dotted line represents the moon.



This observatory has a visible light telescope, and is located in the **United Kingdom**, which follows Universal Time (UTC +0). Hence, the local (clock) time follows UTC exactly.

Please refer to the chart in Page 7 to answer parts a-d.

(a) **From the chart**, what can you see in the sky at 2100 hours UTC? [2]

(b) **From the chart**, which phase is the moon in? [1]

(c) **Hence**, explain why it is not a good idea to be looking at M1 at 2300 hours. [2]

(d) The chart can tell us the time that some of the deep sky objects (DSOs) rise or set (go above or below the altitude of 0° over time).

The DSOs mentioned in the graph are: M8, M16, M1, M82, M76.

Hence, if we want to use the observatory, state the order of DSOs that we should observe over the night. [3]

[Note: Due to technical limitations of the telescope and the obstruction of trees near the horizon, the telescope is unable to view anything below 20° in altitude.]

You do not need to refer to the chart to answer parts e-j below.

(e) On the celestial sphere, how do we identify the local sidereal time? Define explicitly any points, lines/curves/circle on the celestial sphere, area of the celestial sphere and concepts related to the celestial coordinate systems in your answer. [2]

(f) State and explain a possible reason why it may be important to know the local sidereal time when operating the observatory telescope to look at a particular DSO of known right ascension. [3]

(g) In terms of the observing conditions below, circle the one that would be more optimal and explain your answer. [4]

Humidity: high humidity / low humidity
Explanation:

Wind: stable, smooth wind / strong gusting wind
Explanation:

Rain: rain / no rain
Explanation:

Elevation above sea level: at sea level / on a mountain (2000 meters above sea level)
Explanation:

As this observatory is located in the United Kingdom, in November, temperatures change **drastically** as the sun sets, falling significantly from **9-10 degree Celsius at evening** to **1-2 degree Celsius at night**.

(h) Since we are observing objects at infinity, we can adjust the focus of the telescope to a certain point where there is optimal focus of the image, regardless of the object we are looking at. However, in practice, we would still need to adjust the focus as time passes and the sun sets. Explain a possible reason why we need to do so. [3]

(j) How do adaptive optics improve the image captured by ground-based observatories? [2]

(k) Lasers are used by observatories, especially those with adaptive optics, as part of the preparation process before they begin to observe DSOs. Why are lasers helpful for adaptive optics? [3]

END OF PAPER