AstroChallenge 2023
Senior Observation Round

Monday 29th May 2023

PLEASE READ THESE INSTRUCTIONS CAREFULLY.

1. This paper consists of **18** printed pages, including this cover page.
2. Do **NOT** turn over this page until instructed to do so.
3. You have **2 hours** to attempt all questions in this paper.
4. At the end of the paper, submit this booklet together with your answer script.
5. Your answer script should clearly indicate your name, school, and team.
6. It is your responsibility to ensure that your answer script has been submitted.

Team B

Part A: Cloze Passage [20m]

Read the following cloze passages and fill in the blanks in the table below.

Cloze Passage 1

You were cleaning your Astronomy Club's storeroom when you found an old and dusty star book. When you opened it, a piece of paper fell out. Reading it, you realise it was a diary page written by a senior from a long time ago. The diary records down the night sky that he saw on a very clear night. However, this senior is obsessed with using his own terms to name objects, so all key details of objects are essentially encrypted. Please help to decode the objects that he saw on that day. To make things easier, all the terms that he used are replaced by letters.

Date: 21st December 2016

Location: Singapore

Dear diary, I will be doing some stargazing tonight to practice for AC next year. The sun just sat about over an hour ago and the sky is rather clear today. What is it that I'm seeing rising on the eastern horizon? Ah, it is Constellation **A**. I am able to trace out Constellation **A** easily with its 2 brightest stars reddish Star **B** on the left (North) and whitish Star **C** on the right (South). In between Star **B** and Star **C** lies a famous Asterism **D**, which consists of 3 stars in a row. Following the line traced out by Asterism **D**, I can see orange Star **E** higher up in the sky. I can also see **F**, an open cluster which Star **E** is also part of.

Since the sky is so clear today, let me take the chance and try to explore the unfamiliar regions of the sky tonight. On the top right (Southeast) of Star **C**, I can trace out a few dim stars, which eventually leads me to the southern sky, and ending up on a very bright bluish-white Star **G**. These stars that I just traced should be Constellation **H**, which they also call it the "River". Star **G**, which is the brightest star in Constellation **H**, got its name from Arabic, which also translates to "The End of the River". Wow, this means the sky is really exceptional. Okay, let me see what else I'm able to spot. Also in the south, but towards the west of star **G**, I can see a few bright stars as well. I see a red and white star, they should be Tiaki and Alnair respectively, and they both belong to the same Constellation **J**. Constellation **J** got its name from Latin, which translates to the Crane (a bird). Let me see if there are any interesting deep sky objects I can see in the south. Ah, I can see something fuzzy about 20 degrees above the horizon through my binoculars. It is even lower and more south than Star **G**. This should be the famous **K**. It is the smaller of the two major satellite galaxies of the Milky Way. The larger one should be just rising in the southeast now. These two bright satellite galaxies were also called the "Cape Clouds" by sailors from the 15th Century, as they could only be visible when the sailors are far south, such as around Cape of Good Hope in South Africa and Cape Horn in South America. Hmmm, let me write all these down so I can teach them to my juniors next time.

Ok, it is already past 9pm and I can hear the footsteps of the security coming. They will be chasing me away very soon. Let me quickly pack up and go. Good bye.

Signing off,

X

Cloze Passage 1 Answers:

A	
B	
C	
D	
E	
F	
G	
H	
J	
K	

Cloze Passage 2

In order to track the passage of time, Arabs in the Islamic Golden Age used a lunar calendar with 28 lunar stations, located close (but not exactly on) the ecliptic. One of these lunar stations was termed The Ostriches, and was composed of 2 groups of 4 stars, plus a "Keeper of the Ostriches" above and in between them. One group of stars was located within the brightest region of the Milky Way. This group was thus called The Drinking Ostriches, as they were seen as drinking from this rich celestial river. The other group was called The Returning Ostriches. Having had their fill, these ostriches were now going home and had left the confines of this celestial river.

While they are not an IAU constellation today, The Ostriches are still highly regarded, for 8 of the 9 stars in The Ostriches form Asterism **A**. Not only does Asterism **A** contains most of the bright stars of IAU Constellation **B**, but its uniquely identifiable shape also makes it an easy signpost for IAU Constellation **B**. IAU Constellation **B** in turn is well-known in astronomy for its plethora of deep sky objects, including hosting the brightest Messier globular in the night sky, Globular Cluster **C**. This might be surprising, as one usually accords another Messier globular cluster (Globular Cluster **D**) the title of finest globular cluster in the northern hemisphere. But, not only is Globular Cluster **D** fainter than Globular Cluster **C**, for observers in the northern hemisphere Globular Cluster **D** is slightly harder to find. Globular Cluster **D** is located within a constellation that was named after a Greek hero. While Globular Cluster **D** is located within the famous asterism (Asterism **E**) within this constellation, the stars in Asterism **E** are slightly fainter than Asterism **A**, increasing the difficulty of star hopping to Globular Cluster **D**. Hence, if not for the fact that Globular Cluster **C** does not rise very high from the perspective of mid-latitude observers in the northern hemisphere, Globular Cluster **C** would dethrone Globular Cluster **D**.

As the Moon travels past The Ostriches, it soon finds itself in the region of sky known to the Arabs as the ten Auspicious Asterisms. This region is large, spanning 4 lunar stations and containing stars from 3 different IAU constellations. Many of the stars here have names that bear homage to each of the Auspicious Asterisms. For example, Sadalmelik, the alpha star of IAU Constellation **F**, is a reference to the Auspice of the King (sa'd al-malik). While the stars in IAU Constellation **F** are not very bright, the long stream of stars flowing from its Water Jar Asterism terminates at Fomalhaut, one of the brightest stars in the night sky.

After departing the ten Auspicious Asterisms, the Moon passes south of what was known by the Arabs as the Celestial Well Bucket. This asterism contains two lunar stations, each of which is identified by a pair of stars. These 4 stars together form a nearly perfect square, which perhaps explains how it was historically known as the Celestial Well Bucket. Today, the Celestial Well Bucket is better known as Asterism **G**, which is used as a marker for the autumn night sky. Despite the name of Asterism **G**, one of the stars in Asterism **G** (Star **H**) is actually the alpha star of IAU Constellation **J**. IAU Constellation **J**'s main claim to fame is the fact that it contains Deep Sky Object **K**. Not only is Deep Sky Object **K** one of the brightest Messier objects in the Messier Catalogue, it was critical to our understanding of the size of our Universe. By studying Cepheid variables in Deep Sky Object **K**, Edwin Hubble was able to prove that Deep Sky Object **K** was entirely separate from the Milky Way Galaxy.

Cloze Passage 2 Answers:

A	
B	
C	
D	
E	
F	
G	
H	
J	
K	

Part B: Finder Chart [20m]

General Instructions:

1. You will be split into two teams, A and B.
2. Team A will draw a star chart and Team B will use that star chart and try to find the object on Stellarium, and vice versa.
3. Both teams will be given different starting and ending points.
4. You can approach the QMs at the front any time to submit your drawing or to do the finding on Stellarium (provided the other team has already submitted their drawing).
5. Do submit your drawings early so that the other group has enough time to find!
6. Good luck :)

Drawing Instructions:

1. You will be given the finder chart question and a blank piece of paper for drawing.
2. Write your school name and team number (A or B) on the top left corner of the paper.
3. You are not allowed to write the name of the starting point nor the object to be found.
4. Give clear instructions on the equipment to be used.
5. Ensure that your drawing is clear and easy to read. (Put yourself in the other person's shoes, and imagine what kind of drawing you want to receive)

Finding Instructions:

1. You will have **5 minutes** to find the target object.
2. You can **only** use the arrow keys on the keyboard to move around
3. If you want to reset to the starting position, please let the QM know.
4. Let the QM know when you want to change accessories. (Only if it is included in the drawing instructions)
5. If you accidentally exited the ocular view, you will get zero for this component.

Finder Chart Question 2 (Sirius find M47)

It's the start of a new year, and new year means new juniors full of excitement and wonder joining the astronomy club.

As you browse through a star chart app for inspiration on what to find on the telescope next, a group of juniors approach you with a question.

Jnrs: What else is there to see tonight?

You: Unfortunately the only clear patch of sky right now is the Canis Major region. We have already found M41 and the Tau Canis Majoris Cluster so I'm checking to see what else is there. Eh there is M47 which is a star cluster with magnitude 4.4 maybe we could try that.

With bore-sighting and some up-down-left-right you found the cluster.

Jnrs: Oooo. How did you find it?

You: I started out by bore-sighting this star called Sirius in Canis Major, which is also the brightest star in the night sky. Then using the star chart app I slowly star-hopped to M47.

Jnrs: Can we try? Or is it too difficult?

You: Eh it's quite doable actually, don't be intimidated haha. But using the star chart app might be a bit confusing because there are too many stars. I'll help yall out by sketching a finder chart to outline a path you could take from Wezen.

On your star chart app, you adjust the view to contain both Sirius (A) and M47 (B) as shown below. Note grid-lines follow the equatorial grid and each grid line is 1 degree.

Your available equipment has the following specifications:

(a) 50mm finder (5.5 degree FOV, 5x magnification)

(b) 125mm diameter, 600mm focal length Newtonian on alt-az mount

(c) 4mm (50 degree), 15mm (58 degree), 25mm (44 degree) eyepieces

1. Draw a finder chart to aid your junior in star-hopping from Sirius to M47. [8m]

2. Which equipment combination did you choose and why? You may change accessories in between. [2m]

3. Briefly explain what your junior should look out for to be sure he/she has reached the target. Feel free to use sketch(es) to aid in your explanation. [2m]

4. Find the object drawn by Team A. [8m]

*To make things easier, all equipment/accessories are installed with a magical automatic view inverter. This means all the ocular views will be upright!

Part C: Equipment [20m]

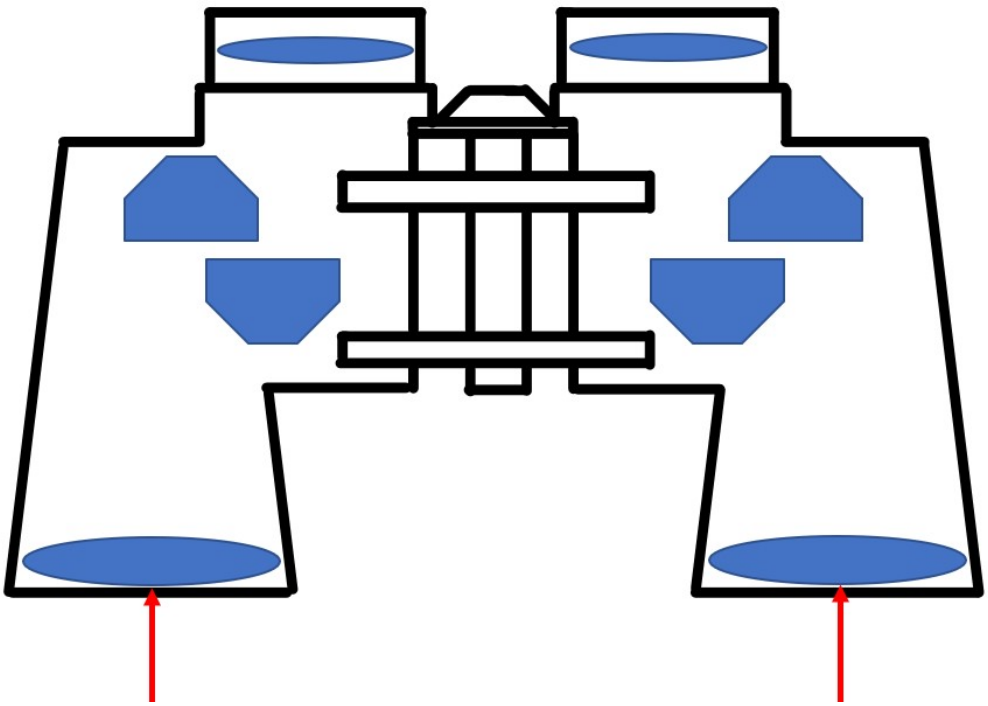
Binoculars are often a starting point for many stargazers. They are much cheaper and affordable, especially for poor students like you and me. They are also much more portable and easier to use compared to a full telescope set up. However, they are many trashy binoculars on the market that are out there to scam our money. Let's see if you know your stuff well enough to avoid the scams.

Let's start off with the basics:

1. On the image below, label the parts of the binoculars: [2m]
    (a) Objective lens
    (b) Focuser
    (c) Eye cup
    (d) Binoculars to tripod adaptor

Binoculars make use of lens and prisms to focus light and form an image. There are mainly two types of binoculars on the market, the porro prism and roof prism binoculars. The main difference between the two binoculars lies in how the prisms are arranged. In roof prism binoculars, the prisms are placed very closely together, making the binoculars very compact as seen in the photo below. However, this makes roof prism binoculars very expensive. Since we are all just some poor students, we will ignore all the expensive stuff and just look at porro prism binoculars.

2. On the image below, complete the light ray diagram of a porro prism binoculars. [2m]



Now that we know roughly how binoculars work, let's take a look at some of the important specifications to look out for when buying binoculars. There are quite a few specifications that are usually given on the product information or manual. These consists of magnification, dimensions, weight, aperture of objective lens, type of coating, type of prism, FOV, exit pupil, eye relief, etc.

The two most important specification of a binoculars are usually written on the body. It is usually in the form of two numbers, $A \times B$, as seen in the image below. This is the key specification as it determines the overall size of the binoculars and what we can see through it. One of the most common and popular specifications is 10×50.

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

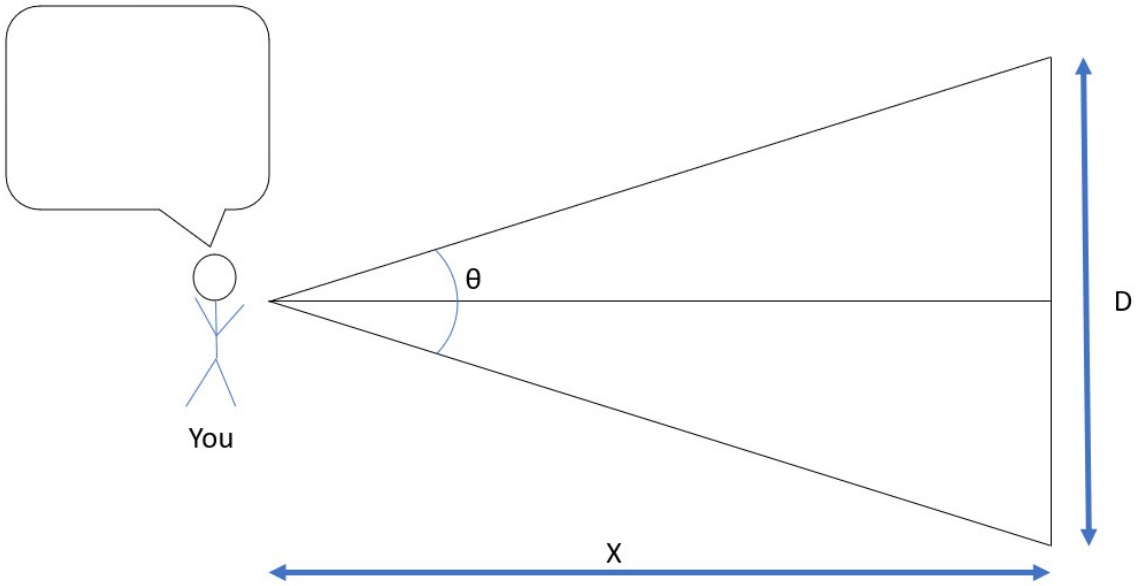
Other than the specification stated above, many specifications are not printed on the binoculars but we should still know them as it will affect the view seen through. Exit pupil and eye relief are two important factors in the usability and comfort of a pair of binoculars.

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

5. Explain the impacts of having a too large and too small exit pupil. [2m]

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

Another key specification of the binoculars is the FOV. This is important as it will affect how much we can see in the night sky. The FOV of binoculars is dependent on many factors other than the magnification. Thus, FOV (θ) is usually calculated from two values that are manually measured. It is given by the distance (D) between the FOV at (@) a certain distance away (X) as shown in the diagram below.



7. Given that in the manual of the binoculars, it states that the FOV is given by 104m @ 914m. Calculate the FOV of this pair of binoculars and round it off to 0.1°. [1m]

Finally! You have enough knowledge about binoculars! You walk into an astronomy equipment shop and the shop owner offers you two pair of binoculars. They are of the same specification and price. However, when looking at the objective lens, you are able to see your reflection clearly on the lens of binoculars A, but only a dark figure of your handsome/beautiful face on binoculars B. The shop owner tells you that binoculars A is better as it has better coating.

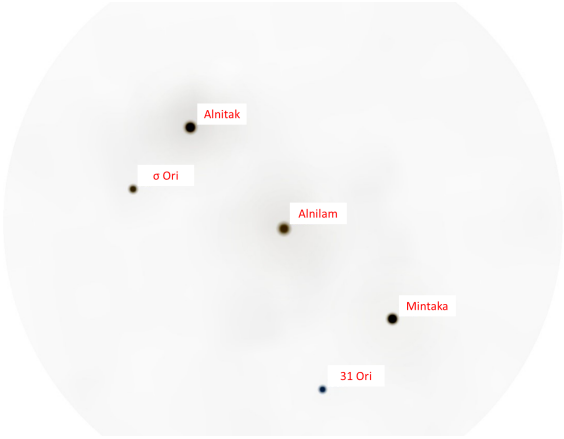
8. Are you being scammed by the shop owner? Explain your answer. [2m]

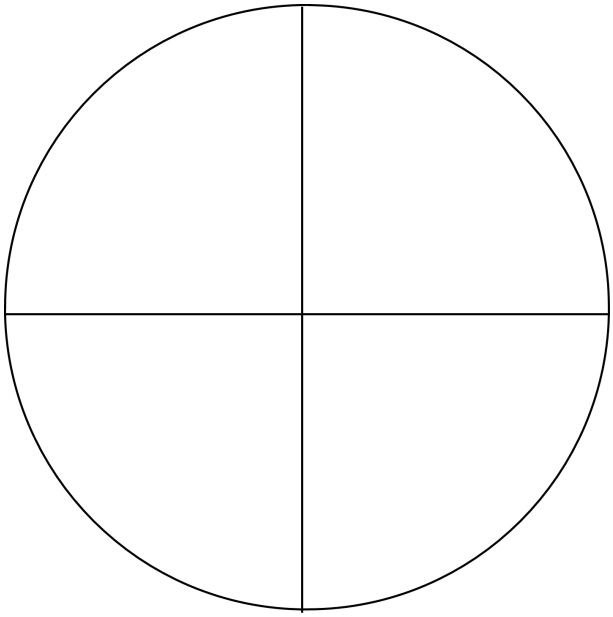
Finder-scopes are a common (but not necessary) component of a telescope setup. However, it is still recommended in many cases. (Unless you are very good).

9. On the above image, label the parts of the finderscope: [1m]
   (a) Finderscope foot
   (b) Tuning screws
10. Explain what the purpose of a finderscope is. [1m]

11. Explain the steps in aligning the finderscope. [2m]

12. The image below shows the FOV of what you will see in a pair of binoculars. In the empty space below, draw and explain what the same FOV will look like in a straight through finder (the one in the image above). Label the stars in your drawing. [1m]





13. There are usually 3 screws in a finder. Explain how the 3 screws adjusts the finder. You many base your explanation on any designs. [2m]

14. Why do most finders not come with a focuser? [1m]

Part D: Night Sky [20m]

It's been 3 years of COVID and you have not left Singapore since 2020. However, your parents decided to go on a holiday around the world without you, leaving you alone at home to study for block tests and A levels. Grinding through papers whilst feeling sad and lonely one evening, you received a call from your parents bragging about their experiences touring the world, and telling you how clear the skies are. They mentioned that they are travelling in the western hemisphere currently but did not tell you the exact location. Annoyed by their gloating tone on your misfortune of having to study, you just replied them with "oh, sounds fun -.-"

Suddenly, your dad decided to send you an image of the night sky taken at his location. He said that if you can decode where they are at now using the image, he will bring you to anywhere in the world after A levels. Feeling motivated, you decided to give it a try. Taking the image your dad sent you, you went out to compare it with the sky in Singapore (Figure 2). Luckily, the sky is very clear that day, there is almost no light pollution and atmosphere is very still, you can see all the way until the horizon. (Both images are attached at the back.)

Both you and your parents are observing at the same time and thus observe the same moon (which is one day after full moon). However, both you and your parents are observing from a different time zone and a different location.

Try to locate where your parents are so they will bring you anywhere free of charge. Local Sidereal Time (LST) of the Moon in Figure 2 is given.

1. On Figure 1, trace out Polaris and label it using the letter **X**. Hence, write the cardinal points using NSEW. [2m]

2. On Figure 2, trace out Crux and label it using the letter **C**. Hence, write the cardinal points using NSEW. [2m]

3. Draw the Local Meridian on both the images and label them **LM**. [1m]

4. On Figure 1, trace out the ecliptic, label it using the letter **E**. Label all planets using the letter **P**. Hint: there is at least one planet. [2m]

5. On Figure 2, trace out the ecliptic, label it using the letter **E**. Label all planets using the letter **P**. Hint: there is at least one planet. [2m]

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

Next, we want to find out the longitude of the location.

7. Given that the Right Ascension (RA) and hour angle of the Moon in Figure 1 is 15h28m and 3h15m respectively, calculate the LST. [1m]

8. Find out the local time at the location of Figure 1, given that you know the LST in Figure 2. Give your answer to the closest hour. Hint: Figure 1 time zone is behind Singapore and there are only 24 time zones. [1m]

9. Hence or otherwise, estimate the longitude coordinate that your parents are at. Give your answer to the closest 10°. [1m]

After decoding the coordinates, your mom wanted to ask for your help to locate some stuff in the night sky, so that she can find them using her binoculars. Initially, you wanted to reject this request, but she said she will bring souvenirs back for you if you help her.

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

11. Label the following stars on Figure 1 using the stipulated letters. [2m]

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

12. On Figure 1, label any 2 constellations, 2 nebulae, 2 star clusters and 2 galaxies. You may not use any objects that you have previously identified in this section of the paper. [4m]

Location A: Unknown

Time: Unknown

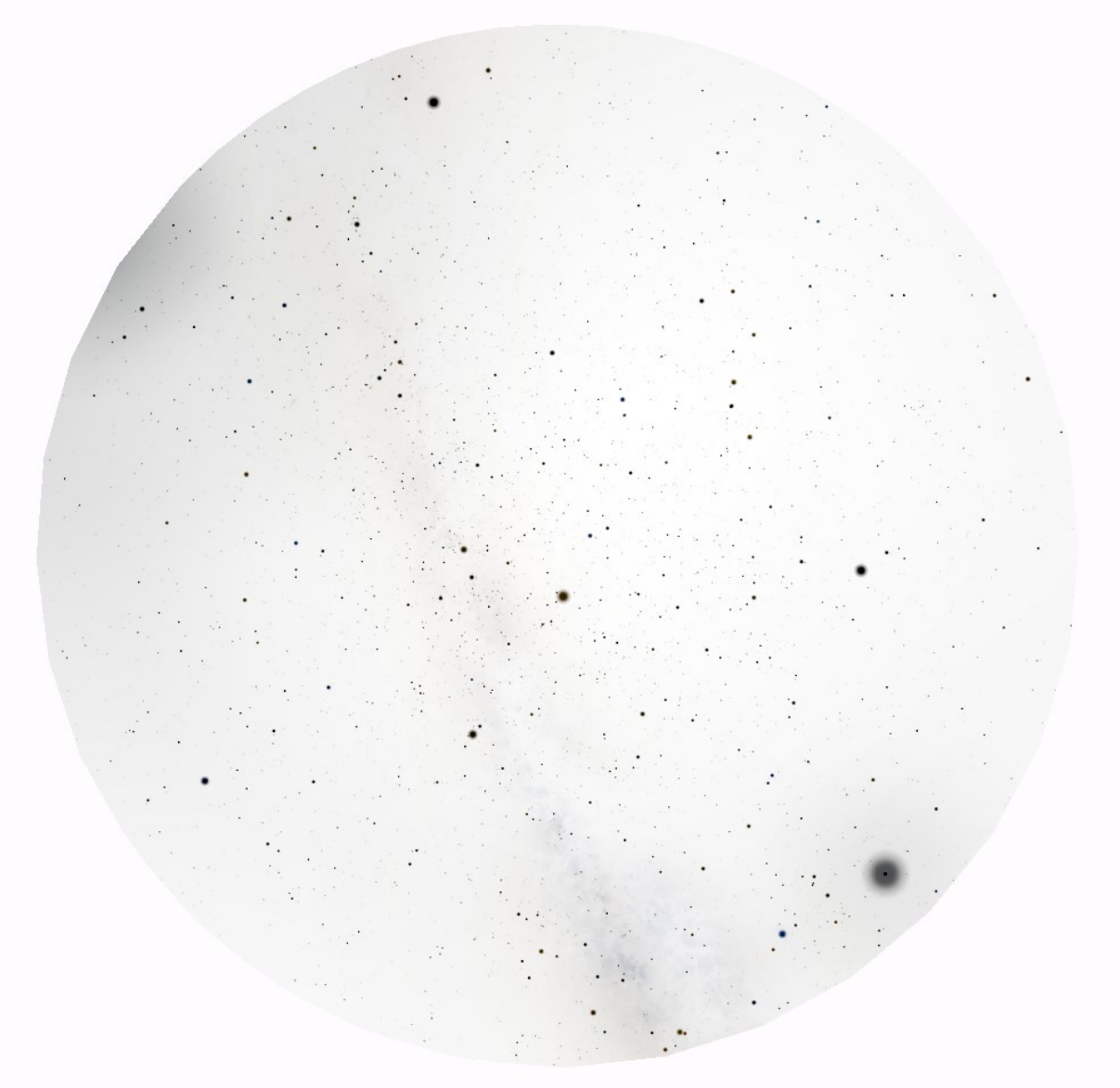


Figure 1: Moon (bottom right)
RA: 15h28m
Hour Angle: 3h15m
Local Sidereal Time: ?

Location: Singapore (+01°17'00", +103°51'00")

Time: 06 May 2023, 2000Hrs local time

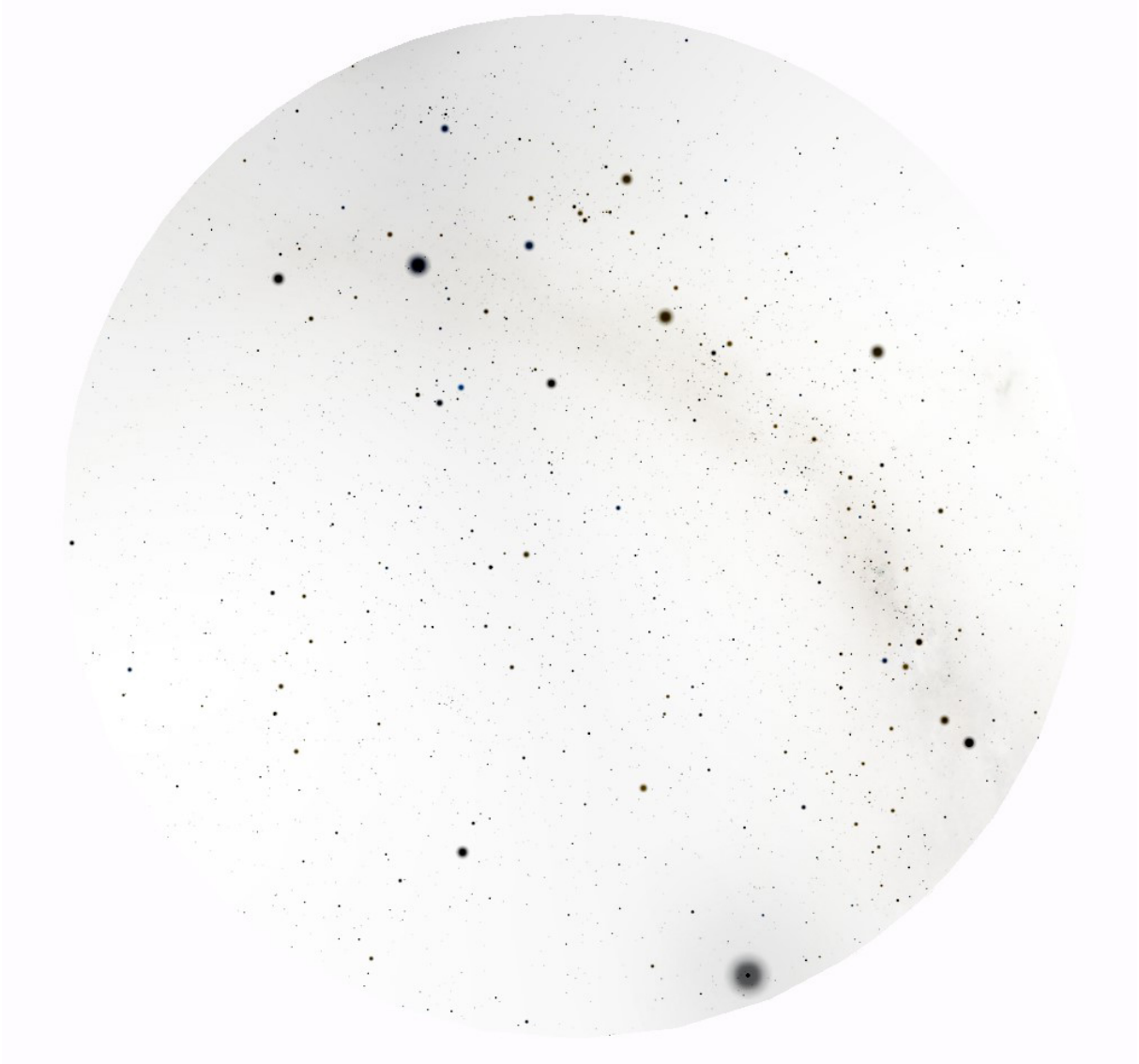


Figure 2: Moon (bottom right)
Local Sidereal Time: 9h51m