Astrochallenge 2020
Observation Round Answers

Section 1: Starlore Cloze [20 Marks]

Cloze Passage 1

In the winter sky, three stars in a line mark a famous winter constellation. In this constellation lies a bright nebula called (A) which contains the Trapezium Cluster. Not far away from A, lying partly on the Galactic Plane is constellation (B). Interestingly, its beta star (C) is brighter than its alpha star.

Moving westward along the ecliptic from (B), we reach a constellation containing deep sky object (D). In his search for comets, Charles Messier created a list of non-comet deep sky objects that distracted him from his goal. (D) is the first object in this list. In the same constellation as (D) lies a prominent star cluster (E) which is so bright it can even be seen with the naked eye in Singapore on a good night.

Antipodal to the famous winter constellation containing (A) lies an asterism known as 'the Teapot'. North of the 'spout' of 'the Teapot' is a deep sky object (F) composed of three types of nebulae: an emission nebula, a reflection nebula and a dark nebula. Further north is constellation (G), the only constellation in the night sky that is split into two parts.

Moving eastwards along the Milky Way from (G), we reach a famous asterism called the Summer Triangle. The Summer Triangle comprises the brightest stars from three summer constellations. One of these three constellations is (H). The brightest star (J) in (H) is interestingly the only star with a magnitude of 0.00 as it was the benchmark star for the magnitude system. (H) also contains the planetary nebula (K).

A: Orion Nebula
B: Gemini
C: Pollux
D: Crab Nebula
E: Pleiades
F: Trifid Nebula
G: Serpens
H: Lyra
I: -
J: Vega
K: Ring Nebula

Cloze Passage 2

Constellation A is one of the 48 constellations identified by the Ancient Greek Astronomer Ptolemy. Its brightest star, a red giant Star B is also the fourth brightest star in the night sky. The Greek name of Constellation A, Arctophylax, means 'Bear Watcher', in view of its location beside the famous Asterism C which points the way to the current North Star Polaris.

Star B is one of the four readily visible red stars in the night sky, the others being Star D, Star E and Star F. While Star B and Star D are both red giants, Star E and Star F are red supergiants, which in itself are quite rare.

Star D lies within a famous open cluster known as the Hyades. However, Star D is not actually part of the open cluster but closer to Earth by more than 60 Light Years compared to Hyades.

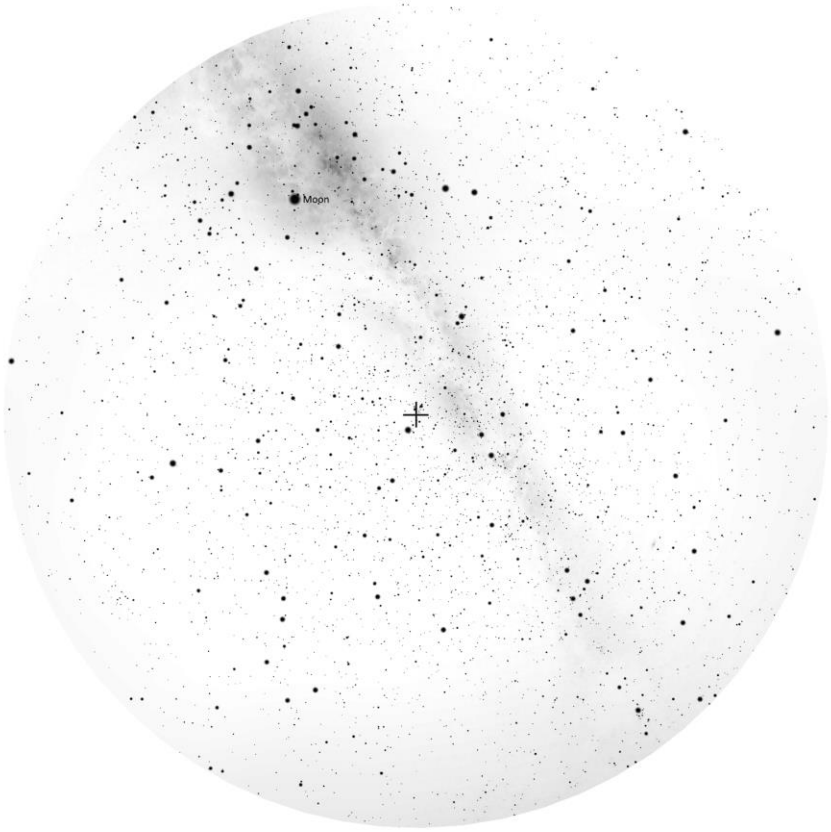
Star E is located quite far south and has a very interesting name. Star E's name means the "opponent to Mars", possibly due to the similar reddish hue as observed.

Star F is the ninth brightest star in the night sky and part of a very famous constellation seen only in winter.

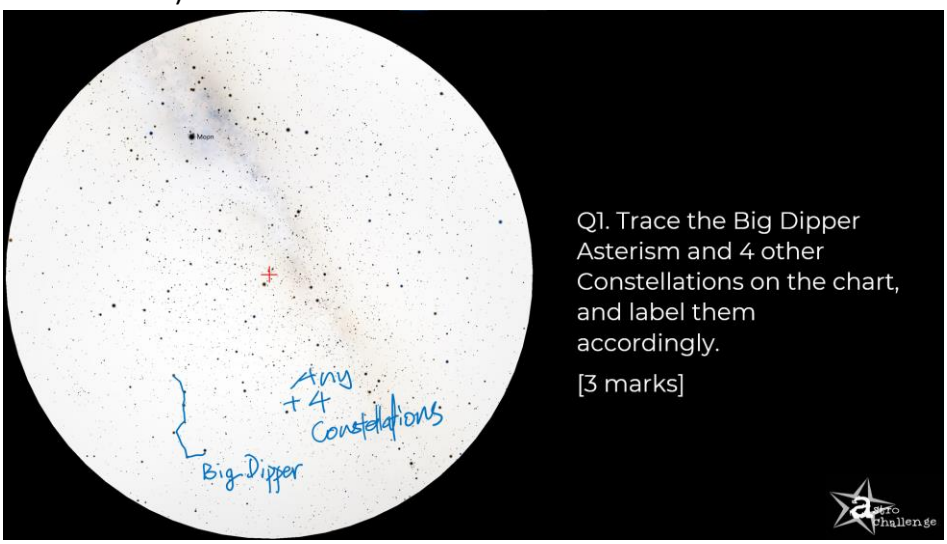
Asterism C also arcs to Star B. If we continue along the arc, we would arrive at the brightest star of Constellation G, Star H. Many galaxies and galaxy clusters are found in Constellation G, which is also the largest constellation of the Zodiac. Due to the effects of precession, one of the points where the ecliptic crosses the celestial equator, The First Point of J, is located in this constellation G. The day the Sun actually crosses the celestial equator at The First Point is J is a very important day. That day is known as K for the Northern Hemisphere.

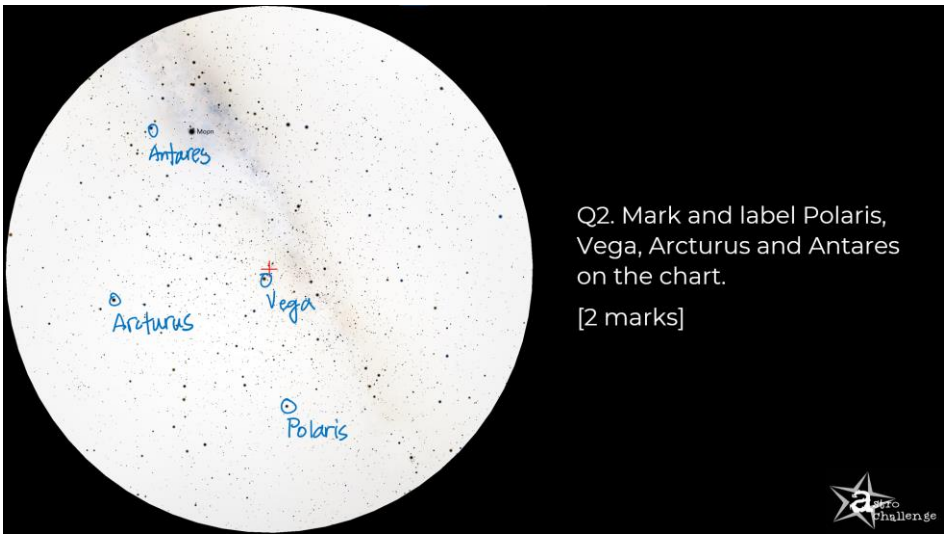
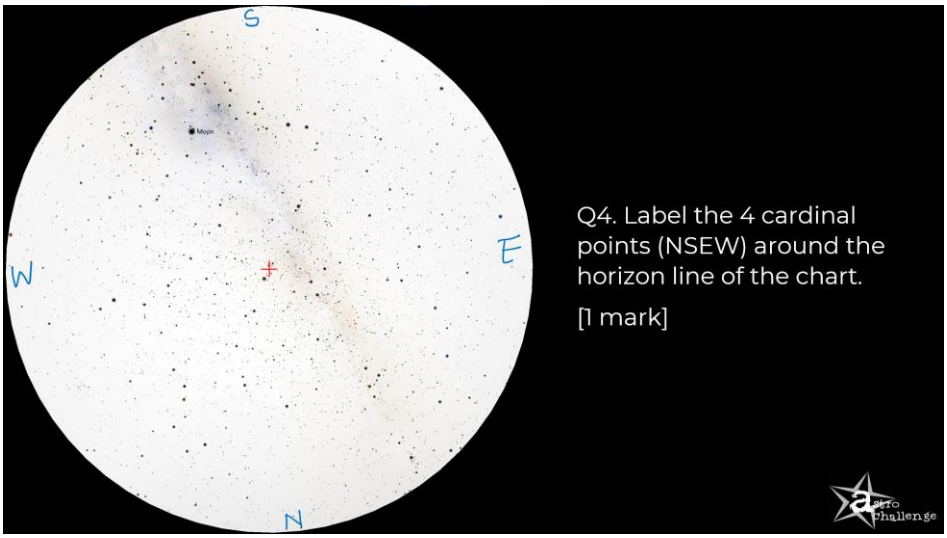
L: Bootes
M: Arcturus
N: Big Dipper
O: Aldebaran
P: Antares
Q: Betelgeuse
R: Virgo
S: Spica
T: Libra
U: Autumnal equinox

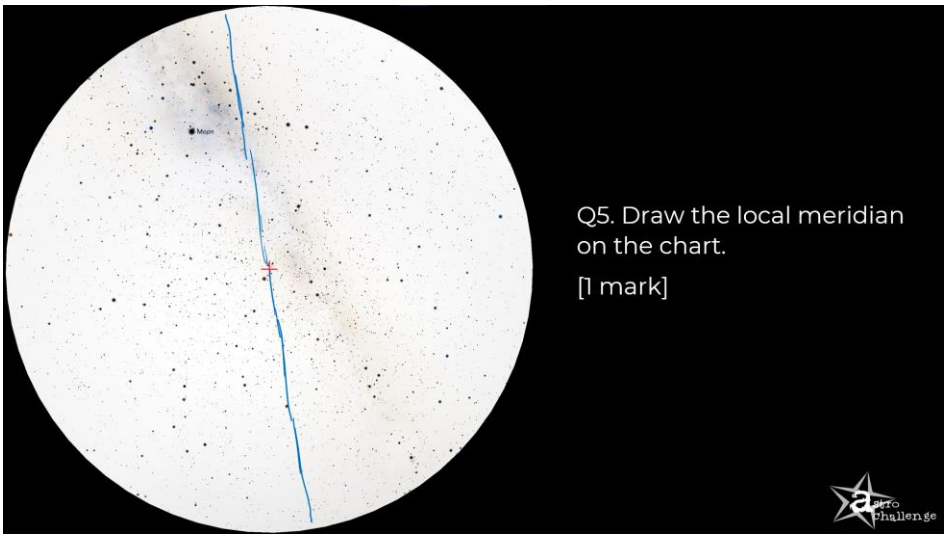
Section 2: No Man's Sky [20 Marks]



The given sky chart (in standard stereographic projection) shows the whole night sky at an unknown location K at an unknown date, local solar time 12 midnight. The rim of the chart is the horizon, and the cross marks out the zenith point (point in the sky directly above the observer). The moon is also labelled on the chart.

Answer	Mark Distribution
1. Trace the Big Dipper Asterism and 4 other Constellations (with labels). 	Total 3 M1 - Big Dipper M0.5 - 1 complete constellation drawn <u>and</u> labeled
2. Identify and label Polaris, Vega, Arcturus and Antares.	Total 2

	M0.5 - For each correctly identified star
3. Mark and label 6 DSOs. Any 6 DSOs with position correctly marked out and name correctly labeled.	Total 3 M0.5 - Marks for each DSO correctly labeled.
4. Mark the 4 Cardinal Points (NSEW) around the circumference of the chart.  Remember that West and East are flipped when we look upwards towards the sky.	Total 1 0.5 marks if East and West are swapped.
5. Draw the Local Meridian.	Total 1



Draw a straight line passing through the zenith point and Polaris.

6. State if is Sagittarius at its upper or lower culmination.

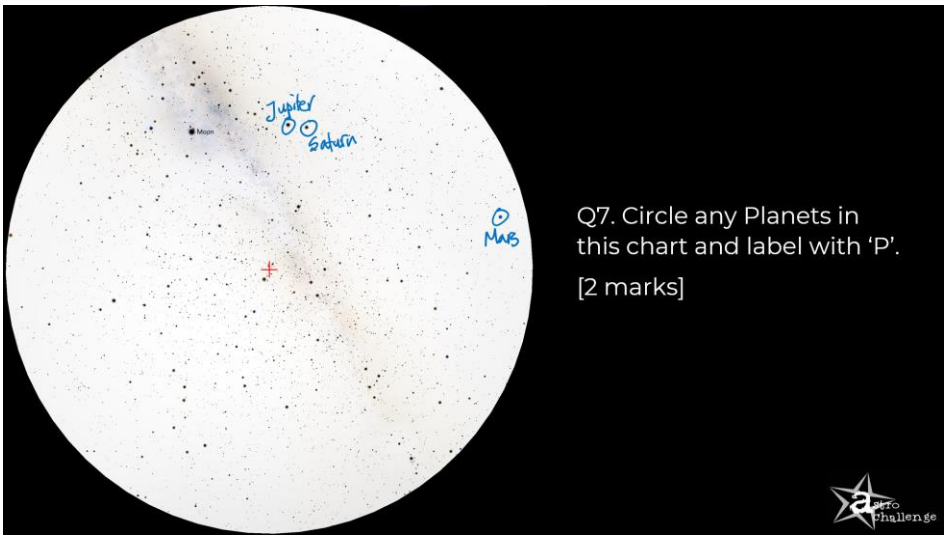
Upper culmination is when an object crosses the meridian at its highest altitude.

In the northern hemisphere, an object is at its upper culmination when it crosses the meridian south of Polaris.

Thus it is at its upper culmination.

Total 1

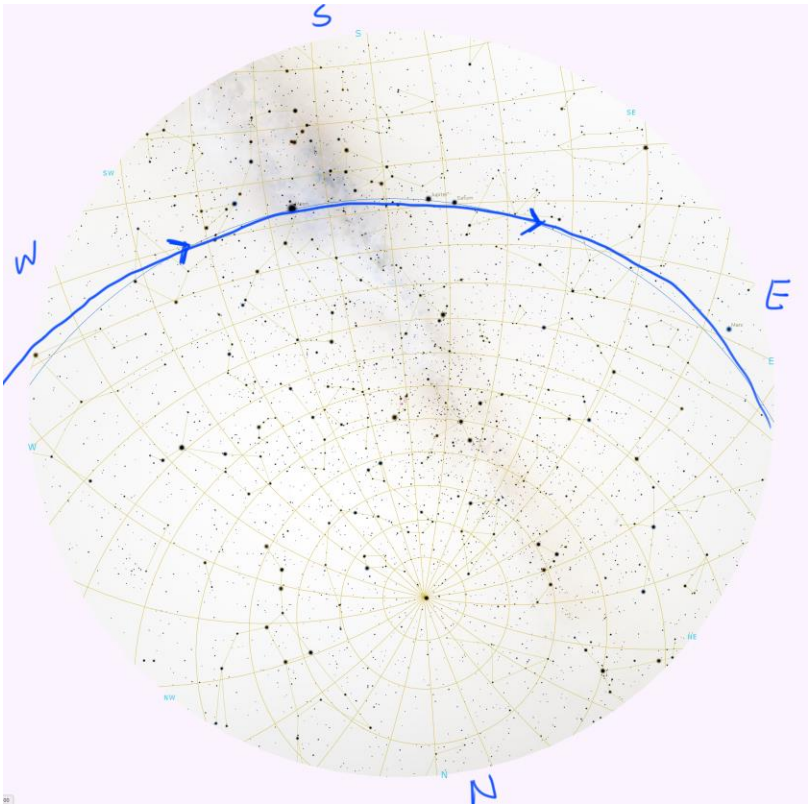
7. Circle any Planets in this image.

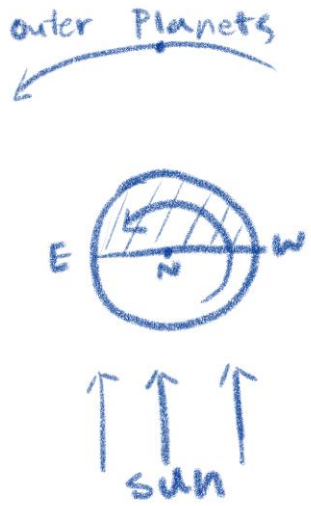
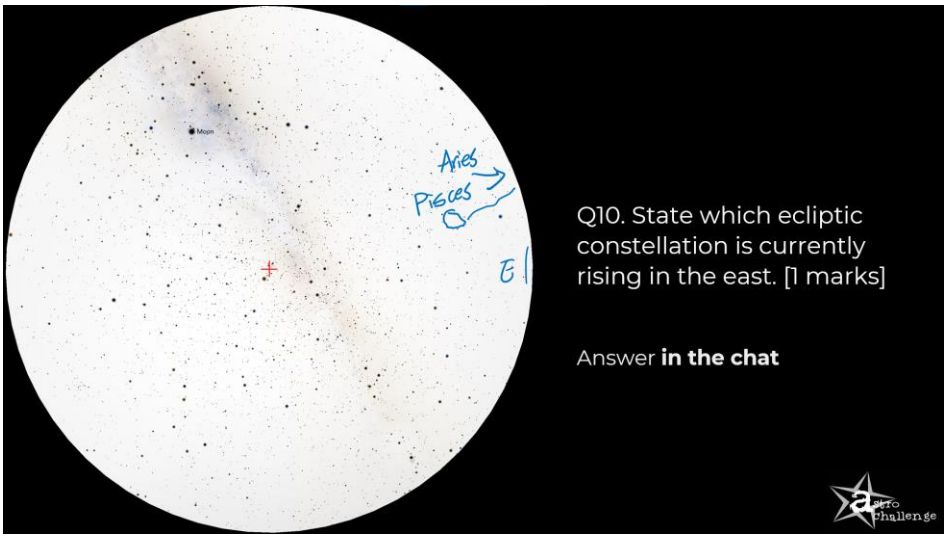


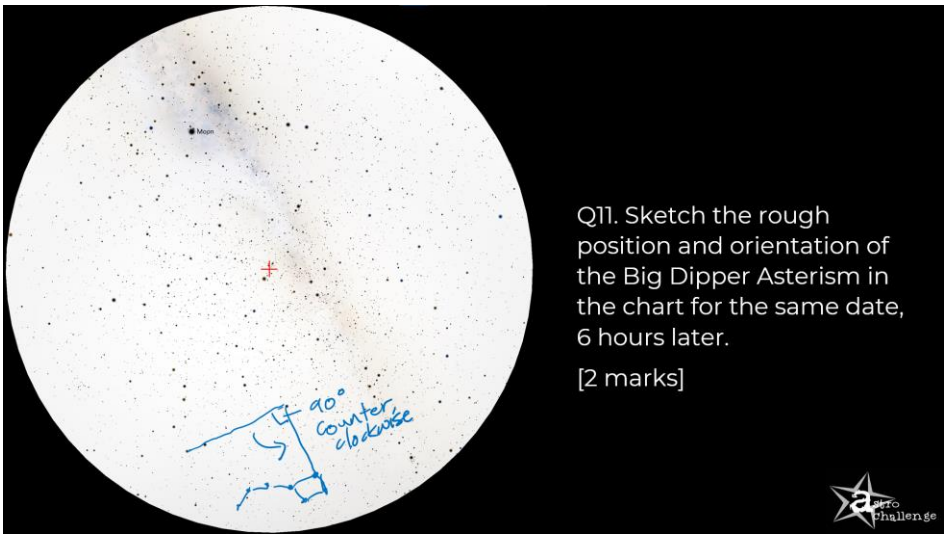
Total 2

M1 for each planet correctly labeled.

Bonus Mark: Mars
+1 mark capped to 20

Jupiter and Saturn can be identified as the two mysteriously bright 'stars' just east of Sagittarius (around Capricorn), when there should not be any bright stars in that region. Participants were not expected to find Mars. If they do, a bonus mark will be given (capped at full marks).	
8. Draw the Ecliptic line and mark with an arrow the direction that planets move across the sky (ignoring retrograde motion).  The ecliptic will appear curved on a stereographic projection (most circular projections as well, except for gnomonic projection), except for when the ecliptic passes through the zenith. Since a straight line drawn through the moon and planets do not pass through the zenith, it must be a curve. The curve should cut through or pass near any labeled planets, as well as the moon (which is only tilted about 5 degrees from the ecliptic). The ecliptic is a great circle, and thus will always cut the horizon at opposite ends. Since the daily rotation of the earth is in the same direction of the rotation of the planets, outer planets appear to move from west to east when not in retrograde.	Total 2 M0.5 - Ecliptic is drawn as an arc. M0.5 - Arc passing through or near the Moon and identified planets (no penalty for mislabeled planets, but if the mislabelling leads to the curve failing other marking points, no ECF marks given). M0.5 - Cuts the horizon roughly 180 on opposite sides (as it is a great circle). M0.5 - Correct Direction labeled. Direction is based on cardinals, ECF if wrongly identified in Q4.

	
9. Taking into account the local solar time given, identify the season. Since Sagittarius is at its upper culmination at local midnight, it is currently summer.	Total 1
10. What ecliptic constellation is currently rising in the east?  The Circlet of Pisces is visible above the eastern horizon, so Pisces is currently rising in the east. Aries is also accepted.	Total 1
11. Sketch the rough position and orientation of the Big Dipper Asterism in the above chart for the same date and location, but at 6am solar time.	Total 2 M1 - Dubhe and Merak are collinear with Polaris (criteria relaxed because participants are bad at



In 6 hours, the sky rotates 90 degrees counterclockwise around Polaris.

zoom drawing)

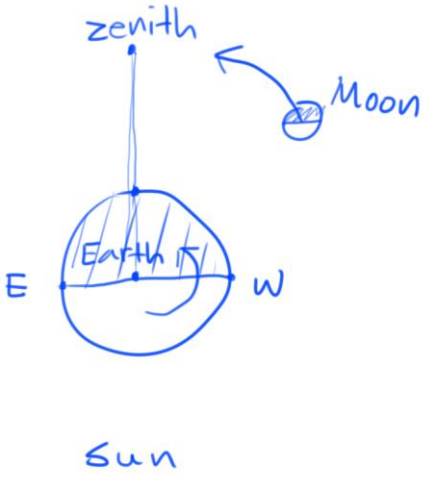
M1 - Line formed is roughly 90 deg <u>counterclockwise</u> with respect to Polaris.

No penalty if position, distance, proportion or scale of constellation is off.

-1 mark if Big Dipper is drawn facing the wrong direction.

12. Based on the local solar time given and the position of the moon, identify the lunar phase (including whether it is waxing/waning).

From the chart, the moon is west of the meridian above the horizon. The moon orbits in the same direction as Earth's rotation.

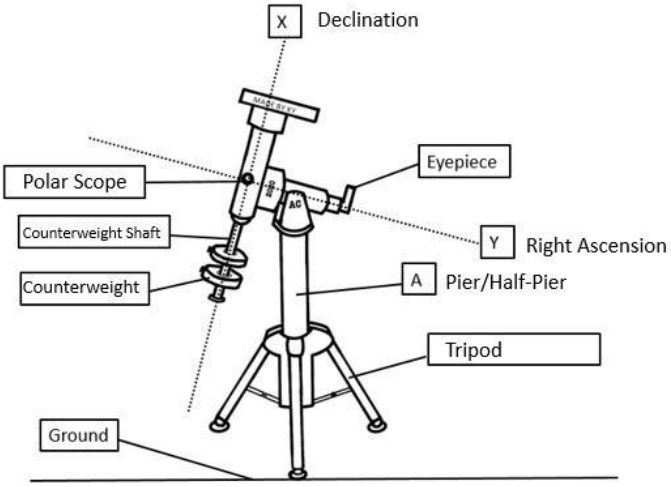


By drawing a diagram, it can be seen that the Moon is in the gibbous phase. Since the moon is approaching opposition (full moon), it is waxing.
Answer: Waxing Gibbous

Total 1

Section 3: Top Gear [20 Marks]

The diagram below shows a typical German Equatorial Mount (GEM).



Q1: Fill in blanks 1-4 above by naming the respective parts of the set up. [2]

Ans: Answer in the diagram. [0.5] each

Q2: Name part A and explain what it is used for. [2]

Ans: A: Pier/Half-Pier. [0.5] It elevates the mount and telescope so that the counterweights don't hit the tripod legs, especially in places of low latitude. [0.5]

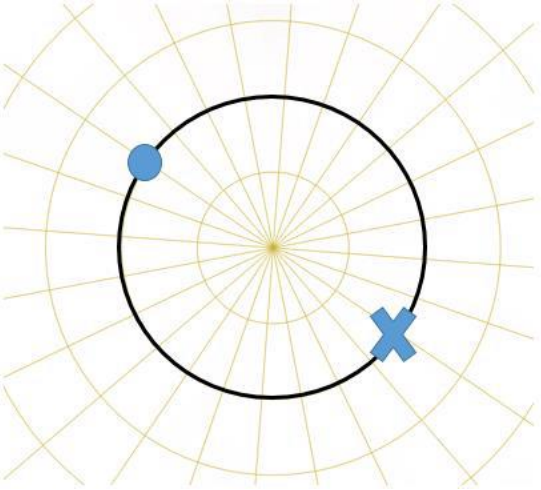
Q3: The GEM has two rotatable axes that help you to find your object in the night sky. Using the diagram, name the axes based on their rotation. [1]

Axis X: _____ Axis Y: _____

Ans: Answer in diagram. [0.5] each

Q4: Briefly explain how the GEM works with regards to the two axes. [2]

Ans: GEM aligns the RA axis to the North using the polar scope. [1] By making use of the two axes, the GEM will point to the object. The RA axis will rotate to counter the rotation of the Earth, while the declination axis remains stationary and point at the object. [1] (1 mark for explaining polar alignment, 1 mark for explaining how the 2 axes work.)



Q5: The star Polaris is often called the North Star as it seems to lie on the North Celestial Pole (NCP). However, it does not lie exactly on the NCP.

i) Assuming the declination of Polaris is about 89°20', mark out a possible position which Polaris can be at with X. Each circle is ⅓ of a degree. [1]
Ans: Anywhere along the black line. [1]

ii) The Earth rotates about the NCP roughly once every day. The star in the diagram below is Polaris at 7:00pm LST. Mark the position of Polaris in 6 months' time at 7:00pm LST with an X. [1]
Ans: Answer in diagram.

Q6: Computerised GEMs often come with the GOTO and tracking function which helps you to find objects in the night sky. However, they also often come with a periodic error which causes the set up to "vibrate" over a period of time. Explain how periodic error can affect a long exposure image even with GOTO and tracking function. [1]

Ans: Periodic error is a small mechanical error in the gears that causes the FOV to "vibrate". During long exposures, these small "vibrations" will become more significant over time and the object taken will not be point sharp. [1]

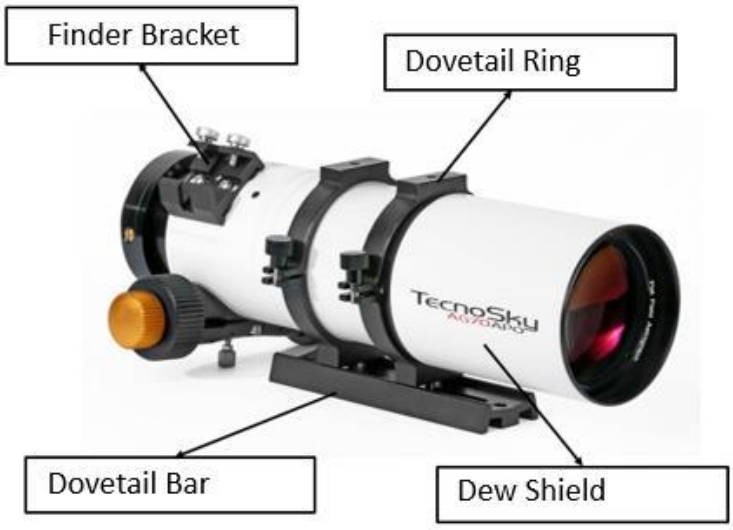
Q7: Suggest an additional equipment to reduce periodic error without changing the mount. [1]

Ans: Auto guiding. [1]

Q8: Assuming the GEM in the diagram is already properly set up, estimate the latitude the observer is at. [1]

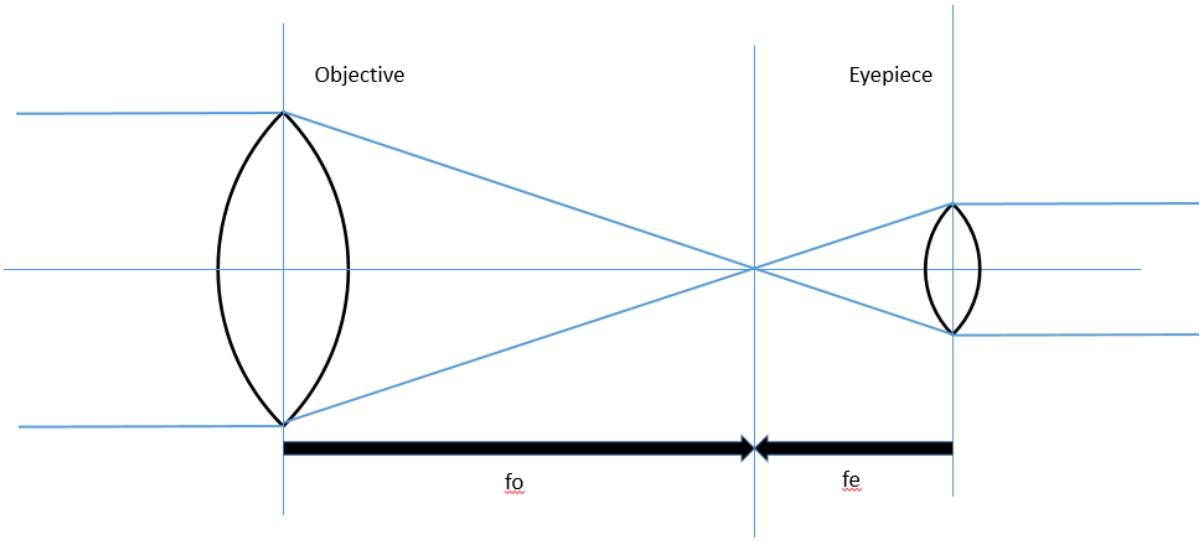
Ans: Accept answers between 15° - 20°. [1] Make use of the ground since it is parallel to the polar axis.

The picture below shows a refractor telescope optical tube assembly (OTA).



Q9: Label parts A-D of the OTA. [2]

Ans: Answer in diagram. [2]



Q10: Assuming light rays from a far away star are travelling parallel to the principal axis, complete the ray diagram above. [1]

Ans: Answer in diagram. [1]

Q11: The human pupil dilates to a size of 7mm in total darkness in youth, and slowly decreases with age. Explain what happens to the image seen when the observer's pupil size is smaller than the exit pupil produced by the telescope. [1]

Ans: Vignetting will occur as the light at the edge will not enter the observer's eyes, causing the edge of the image to darken and even cropped off. [1]

Q12: A single objective lens refractor such as the one shown above has many problems. One such problem is false colour, more commonly known as chromatic aberration.

Explain why such a problem will arise in the design above. [1]

Ans: Different colour wavelengths converge at different focal points/the colours do not converge at 1 single focal point, causing the colours to split and results in chromatic aberration. [1]

Q13: Explain how chromatic aberration can be reduced in refractor designs. [1]

Ans: Use extra-low dispersion glass in making lens elements/using more lens elements to correct the focal point at different wavelengths. [1]

Q14: Reflecting telescopes on the other hand intrinsically do not suffer from chromatic aberration. However, they can be prone to other kinds of optical aberrations. Name 2 types of optical aberrations that can occur in reflecting telescopes. [2]

Ans: Spherical Aberration, Comatic Aberration, Field Curvature. [1] each

Section 4: Manual Plate Solving [20 Marks]

You will be given a set of 4 images of a sector of the night sky in Stellarium. The images are in negative color, of an undetermined field of view. Each individual image is worth a total of 5 marks.

For each image given:
Name and link one complete constellation in each image. [1 mark]
Label and name any 2 bright stars within the image (Common Name/Bayer Designation). [1 mark]
Identify and label three deep sky objects or double stars. They should be:
Sufficiently bright to be captured with a 30 sec exposure with a DSLR OR
From the Messier/Caldwell Catalogues OR
Visual double stars, labeled as a double in addition to its common name/bayer designation.
They do not have to be within the complete constellation identified. [3 marks]

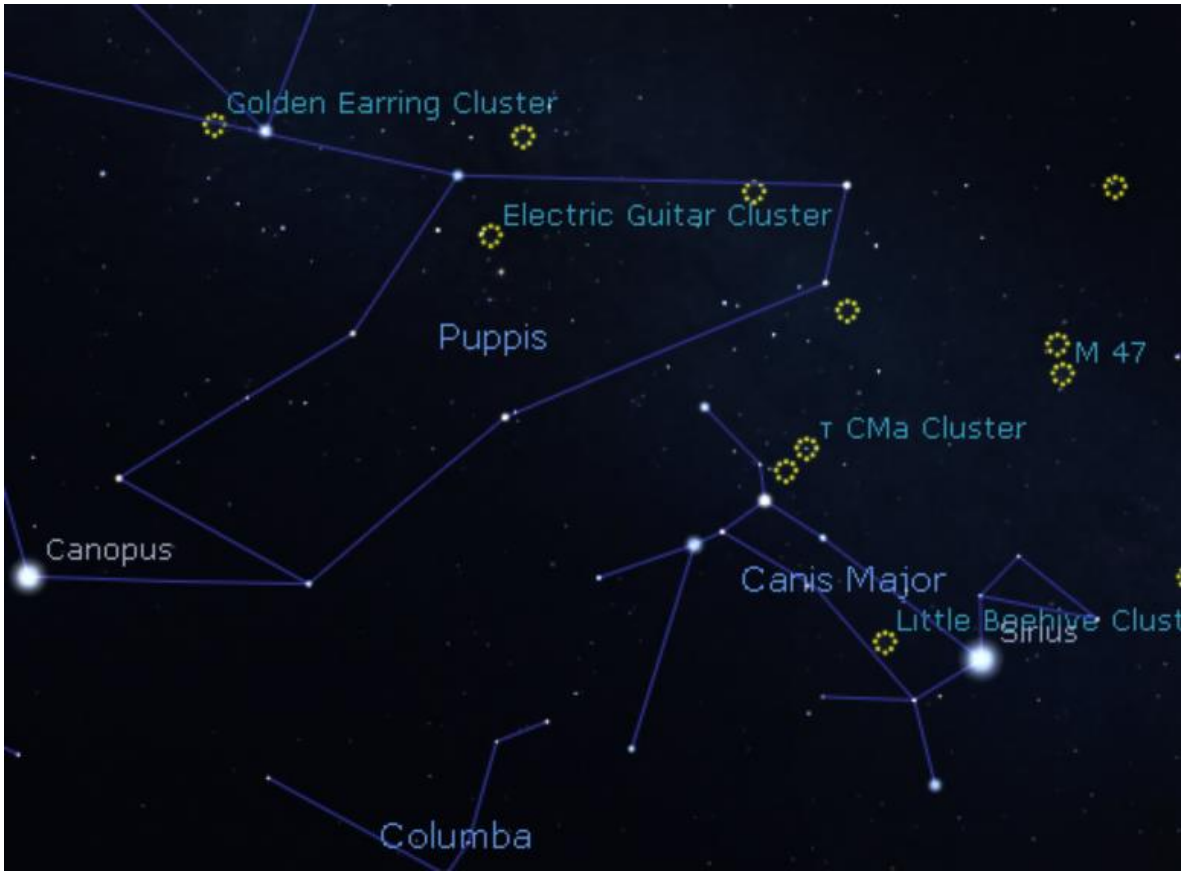
Do not repeat your answers. No additional marks will be given for additional objects identified.

Q1)

Q2)


Ophiuchus
Great Star Cluster in Hercules
Hercules
Summer Beehive Cluster
Tweedledum Cluster
Graff's Cluster
Vega
Lyra
Aquila
Vulpecula
Sagitta
Altair
Angelfish Cluster
NGC 6871
Cygnus

Q3)


Golden Earring Cluster
Electric Guitar Cluster
Puppis
M 47
τ CMa Cluster
Canopus
Canis Major
Little Beehive Clust
Sirius
Columba

Q4)


Queen's Cache Cluster
Wishing Well Cluster
Vela
Pearl Cluster
Hand Cluster
Southern Pleiades
IC 2395
o Vel Cluster
Carina
NGC 2808
Sprinter Cluster