MYAO Question Paper

MALAYSIAN ASTRONOMY OLYMPIAD 2023

Name : .....

Student ID : .....

INSTRUCTIONS

Do not open this booklet until you are instructed by the invigilator.

Time allowed : **2 hours 30 minutes**
Language : **English**

This Question Paper contains:

- **Theoretical: 40 objective questions**
- **Practical: 10 objective questions**
- **Maps and images: 10 objective questions**
- **Students are required to answer all questions**

Answer the questions in the provided OMR Paper. Choose ONLY 1(one) answer for each question:

- **Write your name and shade your student ID**
- **Use 2B PENCIL to shade your answers**

Good Luck!

List of Formula & Constant

Fundamental Constants / *Pemalar Asas*

Speed of light in vacuum / *Kelajuan cahaya dalam vakum*, $c = 2.998 \times 10^{8}$ ms^{-1}

Planck Constant / *Pemalar Planck*, $h = 6.626 \times 10^{-34}$ J s

Boltzmann Constant / *Pemalar Boltzmann*, $k_B = 1.381 \times 10^{-23}$ J K^{-1}

Stefan-Boltzmann Constant / *Pemalar Stefan-Boltzmann*, $\sigma = 5.670 \times 10^{-8}$ W m^{-2} K-4

Charge of electron / *Cas elektron*, $e = 1.602 \times 10^{-19}$ C

Universal Gravitational Constant / *Pemalar Graviti Universal*, $G = 6.674 \times 10^{-11}$N m^2 kg^{-2}

Universal Gas Constant / *Pemalar Gas Universal*, $R = 8.315$ J mol^{-1} K^{-1}

Avogadro Constant / *Pemalar Avogadro*, $N_A = 6.022 \times 10^{23}$ mol^{-1}

Wien's displacement law / *Hukum sesaran Wien*, $\lambda_{max}T = 2.898 \times 10^{-3}$ m K

Mass of electron / *Jisim elektron*, $m_e = 9.109 \times 10^{-31}$ kg

Mass of proton / *Jisim proton*, $m_p = 1.673 \times 10^{-27}$ kg

Mass of neutron / *Jisim neutron*, $m_n = 1.675 \times 10^{-27}$ kg

Atomic Mass Unit (a.m.u.) / *Unit Jisim Atom*, $u = 1.661 \times 10^{-27}$ kg

Astronomical Data / *Data Astronomi*

1 parsec (pc) / *1 parsek (pc)*$= 3.086 \times 10^{16}$ m

Astronomical unit (AU) / *Unit Astronomi*, $a_\oplus = 1.496 \times 10^{11}$ m

Solar Mass / *Jisim Suria*, $M_\odot = 1.989 \times 10^{30}$ kg

Solar Radius / *Jejari Suria*, $R_\odot = 6.955 \times 10^{8}$ m

Solar Luminosity / *Kilauan Suria*, $L_\odot = 3.826 \times 10^{26}$ W

Apparent magnitude of the Sun at mid-day / *Magnitud ketara Matahari pada tengah hari*, $m_\odot = -26.72$ mag

Solar Constant (at Earth) / *Pemalar Suria (di Bumi)*$=$ 1366 W m^{-2}

Apparent angular diameter of Sun / *Diameter bersudut ketara Matahari*, $\theta_\odot = 30' = 0.5°$

Earth Mass / *Jisim Bumi*, $M_\oplus = 5.972 \times 10^{24}$ kg

Earth Radius / *Jejari Bumi*, $R_\oplus = 6.371 \times 10^{6}$ m

1 tropical year / *1 tahun tropika* $= 365.242$ solar days $= 3.156 \times 10^{7}$ s

Theoretical Part

1. If Ahmad was on a return mission from the Moon to an arbitrary planet 9 times the mass of the Moon and 4 times larger than the Moon, How much faster does his rocket need to travel to leave the planet, compared to when it left the Moon?

   (A) 9 times

   (B) 4 times

   (C) 1.5 times

   (D) 0.667 times

2. An arbitrary planet B completes an orbit every 250 rotations on its axis. Meanwhile its sister planet, planet C orbits the same star for every 1080 rotation that planet B made. How many times bigger is the semimajor axis of planet C's orbit compared to planet B's?

   (A) 4.32 times

   (B) 18.66 times

   (C) 2.65 times

   (D) 8.98 times

3. The James Webb Space Telescope is currently orbiting the Sun at an average of 1.5 million kilometers from the Sun. If you are designing a new space telescope 10 times heavier than JWST with the same orbital period as JWST, what is its average distance from the sun?

   (A) 1.5 million km

   (B) 15 million km

   (C) 0.015 million km

   (D) 1.7 million km

4. Asteroid A of 12 kg mass is heading for a collision with Asteroid B at an acceleration of 5 ms^{-2}. After the impact, they both stay stationary. What is the mass of Asteroid B if it was accelerating towards Asteroid A at 2 ms^{-2} before the impact?

   (A) 60 kg

   (B) 75 kg

   (C) 4.8 kg

   (D) 30 kg

5. After collecting some samples from a stationary asteroid, an arbitrary space probe launched itself to go back to Earth. At launch, the space probe accelerates $40ms^{-2}$ and the asteroid accelerates $3ms^{-2}$ in the opposite direction. How much heavier is the asteroid compared to the space probe?

   (A) 13.33

   (B) 0.075

   (C) 3.65

   (D) 0.27

6. You are observing an inferior planet transiting your mother star. If the inferior planet orbits 2.5 times every time your planet orbit the star, how long do you have to wait to see the same planet transiting the mother star again, in term of the inferior planets orbit? (Assume the orbits of both planet are circular and coplanar)

   (A) 1.67 orbits

   (B) 0.67 orbits

   (C) 1.5 orbits

   (D) 2.5 orbits

7. Imagine standing on a planet, and you observe a superior planet at 90^0 elongation from the mother star. Estimate the distance between the two planets if the planets are 3 AU and 7 AU from the mother star respectively.

   (A) 6.32 AU

   (B) 40 AU

   (C) 58 AU

   (D) 7.62 AU

8. If $p = 4$, $q = 5$ and $q = 4p + y^2 - pq$, then, $y =$?

   (A) 31

   (B) 5.57

   (C) 3

   (D) 9

9. Consider two vectors; $u = 3i + 2j$ and $v = 5i - yj$. What is the value of y if $u + v = 8i - 9j$?

   (A) 7

   (B) 11

   (C) 9

   (D) 4

10. Simplify $\frac{(2x^{1/2})^3}{4x^2}$?

    (A) $2x^3$

    (B) 512

    (C) $\frac{2}{\sqrt{x}}$

    (D) $\frac{2}{4\sqrt{x}}$

11. Recent observations by Keck Observatory in Hawaii, the Large Binocular Telescope in Arizona and Apache Point Observatory in New Mexico have discovered auroras in the atmospheres of the four Jovian moons, Io, Europa, Ganymede and Callisto. The auroras were observed from Earth when these moons entered the shadow of Jupiter.

    Which statement below is **COMPLETELY CORRECT** concerning how these auroras in the atmospheres of the moons were formed.

    (A) Cosmic rays collide with the oxygen molecules in the moons' atmospheres and excite these molecules to higher electron energy states. The electrons will then fall back to lower energy states, and light is emitted and the auroras become visible.

    (B) Charged particles in the solar wind collide with the oxygen molecules in the moons' atmospheres and excite these molecules to lower electron energy states. As the electrons jump up to higher energy states, light is emitted and the auroras become visible.

    (C) Charged particles in the solar wind collide with the oxygen molecules in the moons' atmospheres and excite these molecules to higher electron energy states. These electrons will then fall back to lower energy states, light is emitted and the auroras become visible.

    (D) Charged particles in the solar wind collide with the nitrogen molecules in the moons' atmospheres and excite these molecules to higher electron energy states. These electrons will then fall back to lower energy states, light is emitted and the auroras become visible.

12. A Newtonian telescope has an aperture of 150 mm with a primary mirror focal length of 1,200 mm. This telescope is used to observe craters on the Moon by using an eyepiece of 25 mm focal length together with a X2 Barlow lens. What is the magnification of the telescope using this configuration?

    (A) 48 X

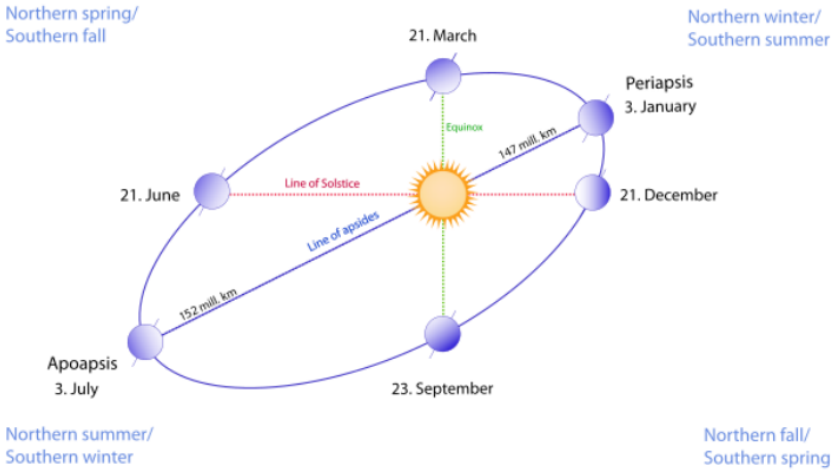
    (B) 72 X

    (C) 96 X

    (D) 192 X

13. The picture below shows the elliptical orbit of the Earth around the Sun.

    Which statement below is **COMPLETELY CORRECT** concerning the speed at perihelion and speed at aphelion for the Earth?



(A) Speed at perihelion = 30.55 km/s
Speed at aphelion = 29.99 km/s

(B) Speed at perihelion = 11.2 km/s
Speed at aphelion = 10.2 km/s

(C) Speed at perihelion = 29.29 km/s
Speed at aphelion = 30.29 km/s

(D) Speed at perihelion = 30.29 km/s
Speed at aphelion = 29.29 km/s

14. Which statement below on stellar evolution is **COMPLETELY CORRECT**.

(A) The more massive the star, the longer is its lifetime

(B) The less massive the star, the longer is its lifetime

(C) The hotter the surface temperature of the star, the longer is its lifetime

(D) The cooler the surface temperature of the star, the longer is its lifetime

15. The picture below shows the Ingenuity Helicopter flying in the Martian atmosphere. Behind it in the distance is the Perseverance Rover on the surface of Mars. Which statement below is **COMPLETELY CORRECT** concerning the ability of the Ingenuity Helicopter to be able to fly in the atmosphere of Mars.

(A) Ingenuity Helicopter made its flights in Jezero Crater on Mars. The two counter-rotating rotors spin at 2,400 revolutions per minute in the thin carbon-dioxide atmosphere of Mars.

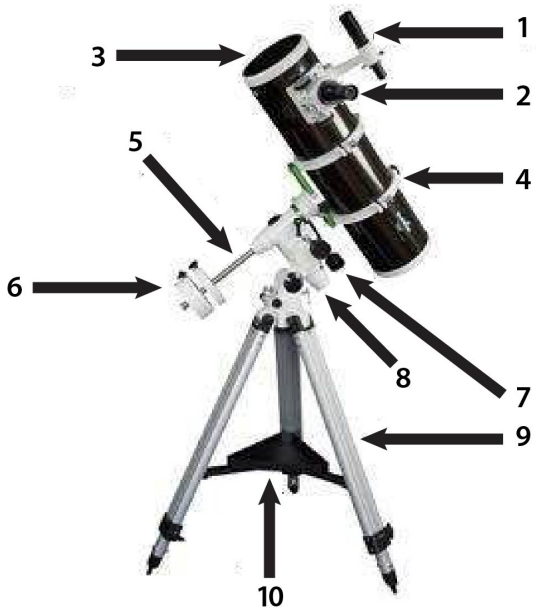
(B) Ingenuity Helicopter made its flights in Gale Crater on Mars. The two counter-rotating rotors spin at 2,400 revolutions per minute in the thin carbon-dioxide atmosphere of Mars.

(C) Ingenuity Helicopter made its flights in Utopia Planitia region on Mars. The two counter-rotating rotors spin at 2,400 revolutions per minute in the thin carbon-dioxide atmosphere of Mars.

(D) Ingenuity Helicopter made its flights in Jezero Crater on Mars. The two counter-rotating rotors spin at 2,400 revolutions per minute in the thin nitrogen atmosphere of Mars.

16. The picture below shows a SKYWATCHER EXPLORER 150P 150 mm f/5 Newtonian Telescope on an Equatorial Mount EQ3-2. Also shown are the arrows pointing to various parts of the telescope.

    Which of the statements below is **NOT COMPLETELY CORRECT**.



(A) 1. Finderscope
2. Eyepiece
3. Aperture of telescope
4. Clamp for telescope tube
5. Counterweight rod
6. Counterweight
7. RA and DEC manual controls
8. Polarscope
9. Tripod
10. Accessories tray

(B) 1. Finderscope
2. Eyepiece
3. Aperture of telescope
4. Clamp for telescope tube
5. Counterweight rod
6. Counterweight
7. RA and DEC manual controls
8. Polar axis
9. Tripod
10. Accessories tray

(C) 1. Finderscope
2. Eyepiece
3. Aperture of telescope
4. Clamp for telescope tube
5. Counterweight rod
6. Counterweight
7. RA and DEC manual controls
8. Polar axis
9. Tripod
10. Tray for eyepieces

(D) 1. Finderscope
2. Eyepiece
3. Aperture of telescope
4. Clamp for telescope tube
5. Counterweight rod
6. Counterweight
7. RA and DEC auto tracking
8. Polar axis
9. Tripod
10. Accessories tray

17. Multi-messenger astronomy is astronomy based on "extrasolar messengers". The four extrasolar messengers are electromagnetic radiation, gravitational waves, neutrinos and cosmic rays. They are created by different astrophysical processes, and thus reveal different information about their sources. Shown below are four types of astronomical equipment used in multi-messenger astronomy.

    Which answer below is **COMPLETELY CORRECT** concerning the matching of the equipment with the extrasolar messengers.

Equipment 1

Equipment 2

Equipment 3

Equipment 4

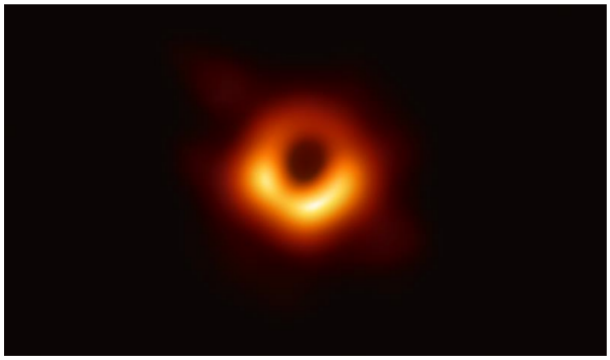
(A) Electromagnetic radiation - Equipment 3
Gravitional waves - Equipment 1
Neutrinos - Equipment 2
Cosmic rays - Equipment 4

(B) Electromagnetic radiation - Equipment 2
Gravitional waves - Equipment 1
Neutrinos - Equipment 4
Cosmic rays - Equipment 3

(C) Electromagnetic radiation - Equipment 1
Gravitional waves - Equipment 2
Neutrinos - Equipment 4
Cosmic rays - Equipment 3

(D) Electromagnetic radiation - Equipment 1
Gravitional waves - Equipment 2
Neutrinos - Equipment 3
Cosmic rays - Equipment 4

18. In April 2019, astronomers released the first image of a supermassive black (diagram below) using the Event Horizon Telescope (EHT). The supermassive black hole is in the centre of the supergiant elliptical galaxy Messier 87. The mass of the supermassive black hole is measured to be 6.5 billion solar masses. Calculate the Schwarzschild Radius of this supermassive black hole in astronomical units (AU).



(A) 100 AU

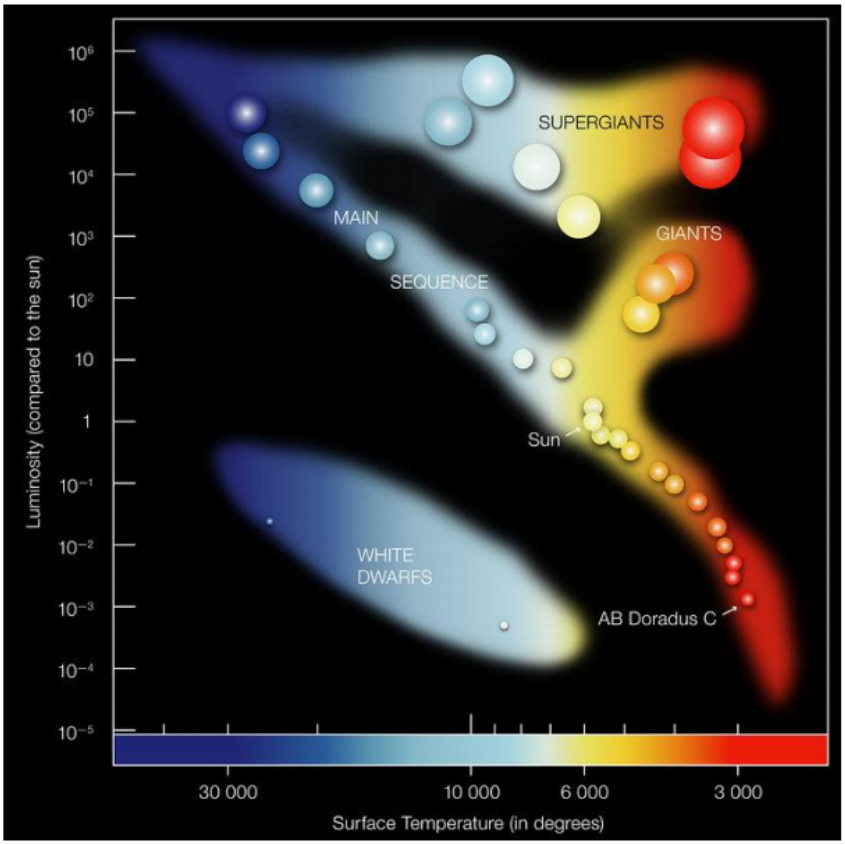
(B) 110 AU

(C) 120 AU

(D) 130 AU

19. The diagram below shows the Hertzsprung-Russell Diagram (HR Diagram), sometimes called the most famous diagram in astronomy. For example, we can use this diagram to explain the evolution of the Sun from its current status as a yellow dwarf on the main sequence to its eventual fate as a black dwarf.

    Which of the statement below explains accurately this evolutionary sequence of the Sun.



(A) The Sun is now 4.5 billion years old and is burning hydrogen in its core to helium. It will then expand into a red giant followed by burning helium in its core into oxygen and carbon. It will then eject its outer layers to form a planetary nebula. The core will shrink and become a white dwarf. The white dwarf will cool and become a black dwarf.

(B) The Sun is now 4.5 billion years old and is burning hydrogen in its core to helium and lithium. It will then expand into a red giant followed by burning helium in its core into oxygen and carbon. It will then eject its outer layers to form a planetary nebula. The core will shrink and become a white dwarf. The white dwarf will cool and become a black dwarf.

(C) The Sun is now 4.5 billion years old and is burning hydrogen in its core to helium. It will then expand into a red giant followed by burning helium in its core to oxygen and carbon. It will continue to expand into a red supergiant followed by burning oxygen and carbon in its core into iron. It will then eject its outer layers to form a planetary nebula. The core will shrink and become a white dwarf. The white dwarf will cool and become a black dwarf.

(D) The Sun is now 4.5 billion years old and is burning hydrogen in its core to helium. It will then expand into a red giant followed by burning helium in its core to oxygen and carbon. It will continue to expand into a red supergiant followed by burning oxygen and carbon in its core into iron. It will then eject its outer layers to form a planetary nebula. The core will shrink and become a brown dwarf. The white dwarf will cool and become a black dwarf.

20. The James Webb Space Telescope (JWST) was launched on 25 December 2021 and is now parked in the Sun-Earth L_2 (Lagrangian) orbit. There are many advantages of choosing the Sun-Earth L_2 orbit to park the JWST in space. Which statement below for the JWST in the Sun-Earth L_2 orbit is **COMPLETELY CORRECT**.

(A) The parking orbit selected is very stable. From time to time JWST can enter into the Earth's shadow but the temperature of the infra-red telescope will always be maintained at -233^0C by using the sunshield.

(B) The parking orbit selected is very stable. Liquid helium is used to continuously maintain the temperature of the infra-red telescope at -233^0C.

(C) The parking orbit selected is very stable. The primary mirror of JWST consists of 18 hexagonal mirror segments made of gold-plated platinum which combined will create a 6.5 meter diameter mirror.

(D) The parking orbit selected is very stable. JWST will never enter into the Earth's shadow and the temperature of its instruments will remain stable at -233^0C. The location of JWST is further away from the Moon so that the infra-red telescope will always be pointed at the universe away from the Sun.

21. Estimate the right ascension of the Sun on 31st August. Hint: when is the vernal equinox and what is the right ascension of the Sun at that date?

(A) 8h 13 m

(B) 10 h 39 m

(C) 11h 12 m

(D) 12h 48 m

22. Estimate the declination of the Sun on 31st August. Hint: what is the declination of the Sun on summer solstice and how does the declination of the Sun change throughout the year? Take the axial tilt of the Earth as $23°26'$.

    (A) $18°53'$

    (B) $19°53'$

    (C) $20°53'$

    (D) $21°53'$

23. Hashim lives in Johor Bahru, near the equator. He observed the culmination of a star and recorded its altitude to be $h = 70°$ and its azimuth $A = 50°$ measured eastwards from the North. What is the star's altitude and azimuth after 12 hours?

    (A) $h = 20°, A = 50°$

    (B) $h = 20°, A = 230°$

    (C) $h = -70°, A = 50°$

    (D) $h = -70°, A = 230°$

24. Hisham lives near the North Pole, but not exactly on the North Pole. He observed a star and recorded its altitude to be $h = 30°$ and its azimuth $A = 70°$ measured eastwards from the North. What is the star's altitude and azimuth after 12 hours?

    (A) $h = 30°, A = 70°$

    (B) $h = 30°, A = 250°$

    (C) $h = -30°, A = 70°$

    (D) $h = -30°, A = 250°$

25. Which one of the following stars can be observed above the horizon by an observer at latitude $\phi = 65°$ and has the most "southern" declination? Neglect any atmospheric refraction. Hint: draw a diagram to derive the relationship between declination, latitude and the altitude of a star culminating south of zenith for an observer in the northern hemisphere.

    (A) Aldebaran, $\delta = 16°31'$

    (B) Procyon, $\delta = 5°13'$

    (C) Rigel, $\delta = -8°12'$

    (D) Fomalhaut, $\delta = -24°22'$

26. Which one of the following stars is circumpolar for an observer at latitude $\phi = 65°$ and has the most "southern" declination? Neglect any atmospheric refraction. Hint: draw a diagram to derive the relationship between declination, latitude and the minimum altitude of a star.

    (A) Deneb, $\delta = 45°17'$

    (B) Aldebaran, $\delta = 16°31'$

    (C) Procyon, $\delta = 5°13'$

    (D) Rigel, $\delta = -8°12'$

27. An alien planet takes 7×10^4 alien-seconds to complete a rotation, and takes 4×10^7 alien-seconds to orbit around its host star. Calculate how many alien-seconds longer is its solar day compared to its sidereal day. You might find it helpful to treat a solar day as $24 \times 60 \times 60$ alien-seconds. Hint: recall the relationship $T = H + R$ for the Sun-Earth system, where T is the local sidereal time, H is the hour angle of the mean Sun, and R is the right ascension of the mean Sun. Consider what happens for $T_2 - T_1$ where T_2 occurs one solar day after T_1.

    (A) 101 alien-seconds

    (B) 151 alien-seconds

    (C) 173 alien-seconds

    (D) 205 alien-seconds

28. Using a photometer (a device that measures brightness), Shufeng found out that a torch light 50 m away has the same flux density with a star 50 light-years away. What is the difference in absolute magnitude between these two light sources?

    (A) 20

    (B) 40

    (C) 60

    (D) 80

29. Astronomers are comparing two stars A and B. A has twice the distance of B, but also twice the peak wavelength of B and twice the radius of B. Calculate the ratio of flux density (perceived brightness) of A to B. Note: if A is brighter, your answer should be greater than 1.

    (A) 4

    (B) 1

    (C) 1/4

    (D) 1/16

30. According to our current understanding of the Universe, the Hubble constant is not a constant but a cosmological parameter that will change according to time. Specifically, we can write $H = \frac{1}{a}\frac{da}{dt}$ where a is the scale factor. We define the scale factor to be 1 at present, and 2 when the Universe is twice as big, etc. Theory also shows that $\left(\frac{da}{dt}\right) = \frac{8\pi G}{3}\rho a^2 + \kappa c^2 + \frac{1}{3}\Lambda a^2$, where the first term correlates to matter density, the second term about the geometry of the Universe, and the third on dark energy, For this problem, assume that our Universe is flat $\kappa = 0$ and has zero dark energy $\Lambda = 0$. What is the value of H when the Universe is half as old?

    (A) $2H$

    (B) H

    (C) $H/2$

    (D) $H/4$

31. The following are 4 stars A, B, C, D and their bolometric apparent magnitude and visual apparent magnitude, in that order, at a similar distance away from us. Choose the star with the highest total luminosity. If the magnitudes of the star do not make sense, ignore those stars.

    (A) 5, 6

    (B) 5, 7

    (C) 7, 5

    (D) 7, 6

32. The following are 4 red dwarves A, B, C, D and their bolometric apparent magnitude and visual apparent magnitude, in that order, at a similar distance away from us. Choose the hottest star. If the magnitudes of any stars do not make sense, ignore those stars.

    (A) 5, 3

    (B) 5, 4

    (C) 5, 6

    (D) 5, 7

33. Which of the following statements is definitely false?

    (A) Spiral galaxies can turn into elliptical galaxies

    (B) The ratio of the number of elliptical galaxies to the number of spiral galaxies is increasing as the Universe ages

    (C) Most nearby galaxies are spiral galaxies

    (D) Elliptical galaxies can turn into spiral galaxies

34. An astronomer would like to estimate the distance to a globular cluster inside the Milky Way. Which distance ladder method is the most suitable? Note: Consider the useful range of parallax up to 100pc.

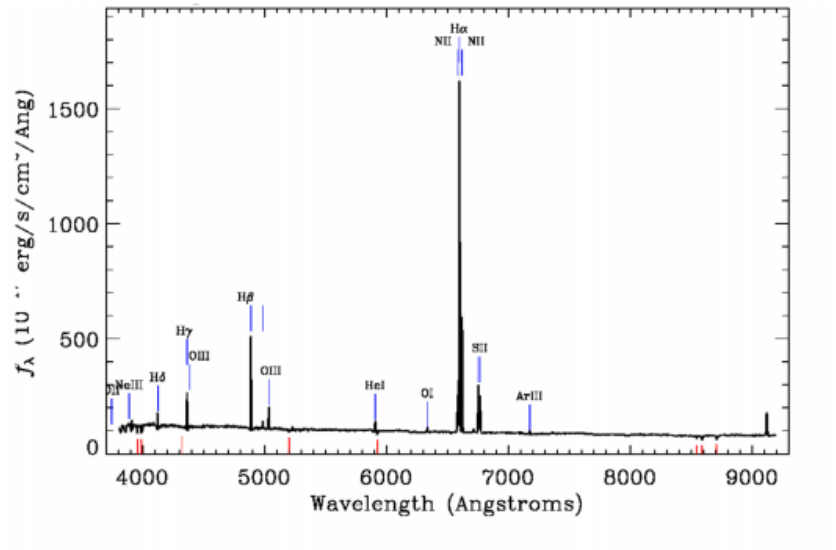
    (A) Radar

    (B) Parallax

    (C) Cepheids

    (D) Type Ia supernova

35. What type of object does the following spectra belong? Hint: which emission line has a peak?



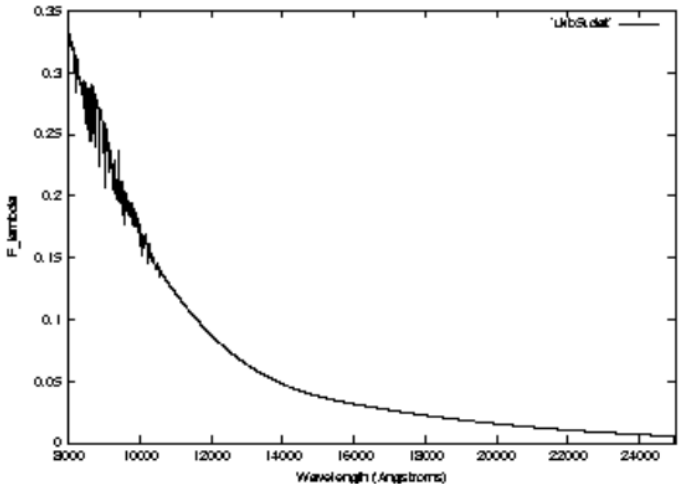
    (A) Spiral galaxy

    (B) Elliptical galaxy

    (C) Blue giant

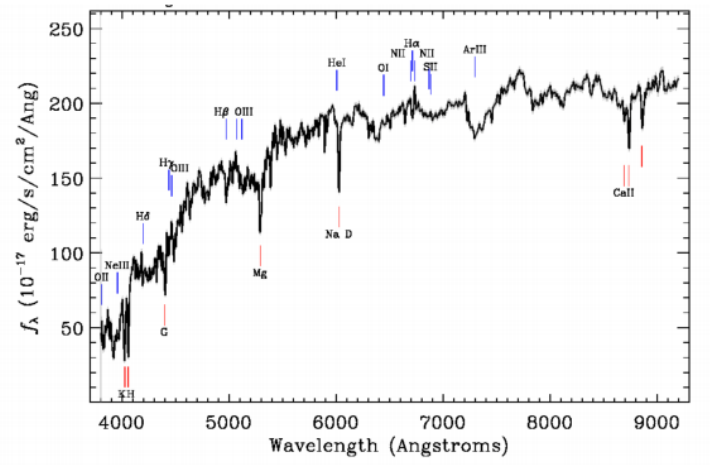
    (D) Red dwarf

36. What type of object does the following spectra belong? Hint: what wavelength region does the spectra peak in?



(A) Spiral galaxy
(B) Elliptical galaxy
(C) Blue giant
(D) Red dwarf

37. What type of object does the following spectra belong? Hint: what range of wavelengths is the spectra measured in?



(A) Spiral galaxy
(B) Elliptical galaxy
(C) Blue giant
(D) Red dwarf

38. Which of the following galaxies are the nearest? Assume that the galaxies have similar composition.

    (A) Apparent magnitude of 9. Estimated 10^{10} stars

    (B) Apparent magnitude of 10. Estimated 10^{9} stars

    (C) Apparent magnitude of 9. Estimated 10^{11} stars

    (D) Apparent magnitude of 10. Estimated 10^{10} stars

39. A friendly alien civilisation at redshift $z = 0.02$ sent us a message! We decide to send a message back via UV. Experts propose that it will be optimal if the aliens receive our message at the wavelength of 100 nm. What wavelength should we use to send the message from an emitter on Earth? Assume that the time spent between the emittance of the message by the alien and their receipt of our message to be insignificant for the redshfit of the alien civilisation to change by much.

    (A) 98 nm

    (B) 100 nm

    (C) 102 nm

    (D) 5000 nm

40. An elliptical galaxy has 2×10^{10} stars. Assume that all of the stars weigh one solar mass (1.989×10^{30} kg). The maximum redshift of a star at the edge of the galaxy is measured to be 0.001. Assume that the redshift of the star is purely due to the rotation of the star about the centre of the galaxy, and the orbit of the star is edge-on to us. Assume that most of the matter in the galaxy is due to the stars. Estimate the proportion of dark matter in the galaxy. Assume that the dark matter and the stars are distributed uniformly as a sphere. The radius of the galaxy is 20 kpc. Take 1 pc to be 3.09×10^{13} km.

    (A) 60%

    (B) 70%

    (C) 80%

    (D) 90%

Practical Part

On 2021 October 3 (UTC), a stellar occultation of the star UCAC4 646-021974 by (3200) Phaethon asteroid, occurred over western Japan. 72 observers from the DESTINY mission team were stationed in 36 stations over western Japan to southern South Korea (Yoshida et.al, 2022). The asteroid's shadow was moving at the speed of 7.9212 kms^{-1}. Observation data from the phenomena is listed in the table below. For simplicity, only a sample of the data set is included here.

Obs. Site	Longitude	Latitude	Detection	Disappearance	Reappearance	Duration (s)	Length of shadow chord (km)
4	$+133^0 58' 52.4''$	$+34^0 15' 42.8''$	N	-	-		
6	$+135^0 14' 56.1''$	$+34^0 02' 44.4''$	P	$17^h 03^m 9.012^s$	$17^h 03^m 09.261^s$	0.249	1.972
9	$+133^0 57' 01.8''$	$+34^0 15' 46.0''$	P	$17^h 03^m 22.848^s$	$17^h 03^m 23.090^s$		
10	$+135^0 08' 50.8''$	$+34^0 03' 14.8''$	P	$17^h 03^m 09.908^s$	$17^h 03^m 10.469^s$		
14	$+135^0 11' 56.5''$	$+34^0 02' 14.6''$	P	$17^h 03^m 09.238^s$	$17^h 03^m 09.976^s$		
16	$+133^0 55' 02.6''$	$+34^0 14' 58.4''$	P	$17^h 03^m 22.874^s$	$17^h 03^m 23.606^s$		
18	$+135^0 10' 22.5''$	$+34^0 01' 50.7''$	P	$17^h 03^m 09.474^s$	$17^h 03^m 10.160^s$		
19	$+133^0 55' 05.6''$	$+34^0 14' 21.2''$	P	$17^h 03^m 22.862^s$	$17^h 03^m 23.491^s$		
20	$+134^0 26' 28.7''$	$+34^0 09' 11.3''$	P	$17^h 03^m 17.324^s$	$17^h 03^m 17.935^s$		
21	$+135^0 10' 47.9''$	$+34^0 01' 15.1''$	P	$17^h 03^m 09.504^s$	$17^h 03^m 09.928^s$		
22	$+133^0 57' 02.9''$	$+34^0 13' 34.4''$	P	$17^h 03^m 22.635^s$	$17^h 03^m 23.002^s$		
23	$+134^0 10' 16.2''$	$+34^0 11' 11.3''$	N	-	-		

Complete the observation table above to answer questions 41 to 45.

In the table, column 1 is the assigned number for the observation site; column two and three is latitude and longitude respectively; column three states the detection of the stellar occultation, N means negative and P means positive; column four is the time of disappearance and reappearance respectively; column five is the duration of the occultation (the duration from the disappearance of the star to its reappearance); and column 6 is the length of chord of the shadow as observed from the respective site (the distance of the straight line forming the segment of the shadow of the asteroid, as seen from respective observation site)

41. How long did the star disappear, as observed from site 4?

    (A) It did not disappear

    (B) It disappear the whole time

    (C) It was cloudy

    (D) Not enough info

42. Which of the values below is correct?

	Obs. Site	Duration (s)	Length of shadow chord (km)
I.	9	0.232	1.838
II.	10	0.561	3.333
III.	14	0.725	5.846
IV.	16	0.732	5.798

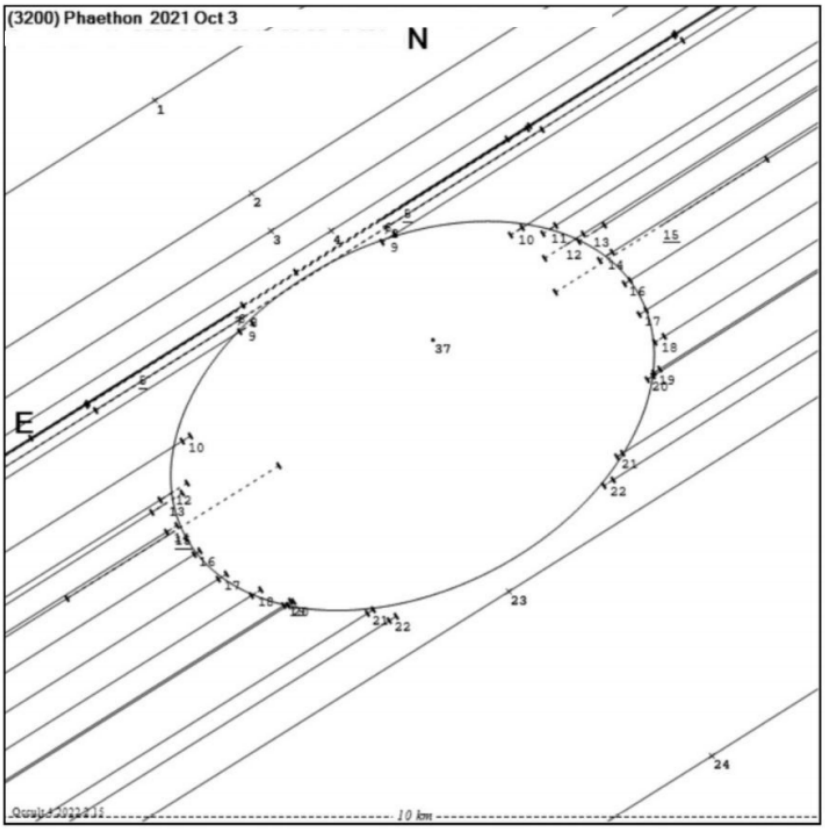
(A) I and II
(B) I and III
(C) IV only
(D) III and IV

43. Which of the values below is **NOT** correct?

	Obs. Site	Duration (s)	Length of shadow chord (km)
I.	18	0.686	5.434
II.	19	0.629	4.84
III.	20	0.367	4.982
IV.	21	0.424	3.359

(A) I and II
(B) I and III
(C) I and IV
(D) III and IV

By converting the latitude and longitude of each observation point to the x and y coordinates of a certain plane and displaying the length of the shadow observed there, the shape of Phaethon's shadow was obtained, as shown in figure below.



44. If we approximate the shape of the asteroid as an ellipse, what is its major diameter?

    (A) 4 km

    (B) 5 km

    (C) 6 km

    (D) 7 km

45. If we approximate the shape of the asteroid as an ellipse, what is its minor diameter?

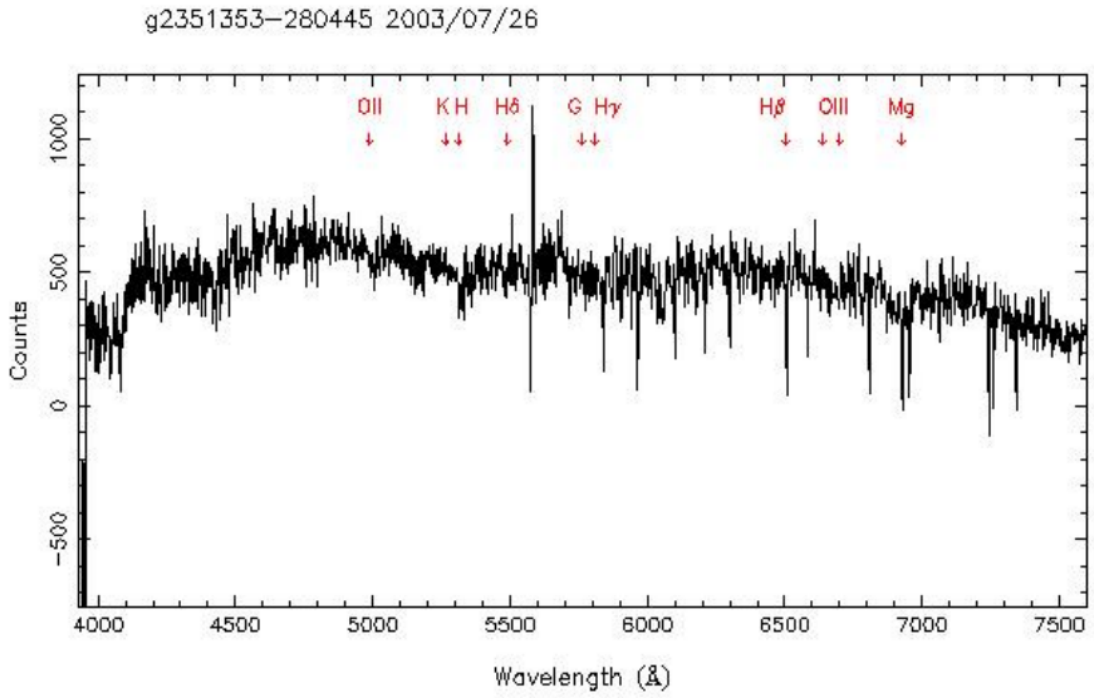
    (A) 4 km

    (B) 5 km

    (C) 6 km

    (D) 7 km

Images below is the spectrum of g2351353-280445 galaxy by the 6dF Galaxy Survey (6dFGS), a combined redshift and peculiar velocity survey over the southern sky. In each plot, important emission lines are marked. **Refer to the plot to answer questions 46 to 50.**



46. What is the wavelength of Hβ emitted by galaxy g2351353-280445?

    (A) 5500 Å

    (B) 6500 Å

    (C) 5800 Å

    (D) 5320 Å

47. What is the wavelength of OII emitted by galaxy g2351353-280445 ?

    (A) 5500 Å

    (B) 6500 Å

    (C) 5800 Å

    (D) 5320 Å

48. Knowing that the rest wavelength of Hβ is 486nm, what is the shift in wavelength for each line from the rest wavelength?

    (A) 6014

    (B) 164

    (C) 5014

    (D) 64

49. At what speed does the galaxy move?

    (A) 12.37c

    (B) 10.31c

    (C) 0.13c

    (D) 0.33c

50. At which direction is the galaxy moving towards?

    (A) Away from us

    (B) Toward us

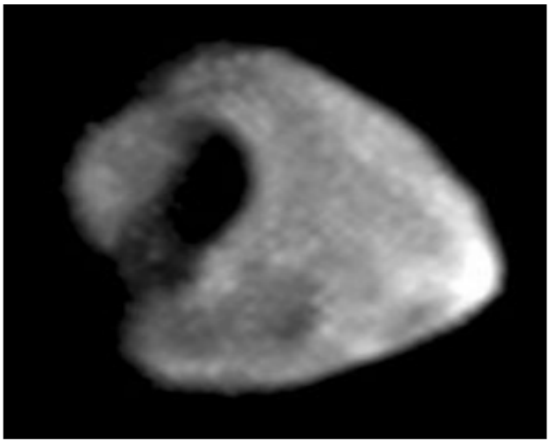
    (C) To the left

    (D) To the right

Maps and Images Part

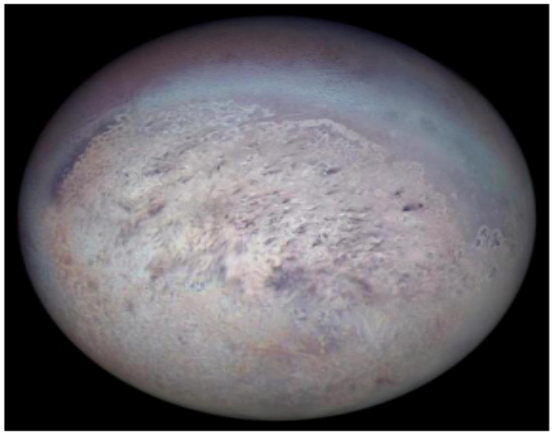
51. The four pictures above show four of the moons orbiting the planets in the Solar System. Which of the answer below is the **COMPLETELY CORRECT MATCH** of the moons with the planets that they are orbiting.

moon 1



moon 2

moon 3



moon 4

(A) moon 1 - Uranus
moon 2 - Jupiter
moon 3 - Saturn
moon 4 - Mars

(B) moon 1 - Saturn
moon 2 - Jupiter
moon 3 - Mars
moon 4 - Neptune

(C) moon 1 - Jupiter
moon 2 - Saturn
moon 3 - Uranus
moon 4 - Neptune

(D) moon 1 - Saturn
moon 2 - Jupiter
moon 3 - Neptune
moon 4 - Uranus

52. Altogether there are 88 constellations, large and small. Which answer below is the correct one starting from the largest constellation to smaller and smaller constellations.

    (A) VIRGO to AQUARIUS to LEO to ANDROMEDA

    (B) HYDRA to CASSIOPEIA to ARIES to ORION

    (C) VIRGO to ERIDANUS to CANIS MINOR to CRUX

    (D) HYDRA to URSA MAJOR to CAPRICORNUS to CRUX

53. Picture A is a panoramic picture of the Milky Way. Many constellations can be seen in this picture. In Picture B are seen four constellations indicated by the numbers 1, 2, 3 and 4. Which of the statements below is **COMPLETELY CORRECT** concerning the locations of the four constellations.

Picture A

Picture B

(A) 1 - SAGITTARIUS
    2 - LIBRA
    3 - CAPRICORNUS
    4 - CYGNUS

(B) 1 - SCORPIUS
    2 - SAGITTARIUS
    3 - AQUILA
    4 - CYGNUS

(C) 1 - LEO
    2 - AURIGA
    3 - CAPRICORNUS
    4 - CYGNUS

(D) 1 - SAGITTARIUS
    2 - SCORPIUS
    3 - AQUILA
    4 - CYGNUS

54. Not all stars and constellations are visible from everywhere on Earth at night. Which statement below on the visibility of stars and constellations on the Earth is **COMPLETELY CORRECT**.

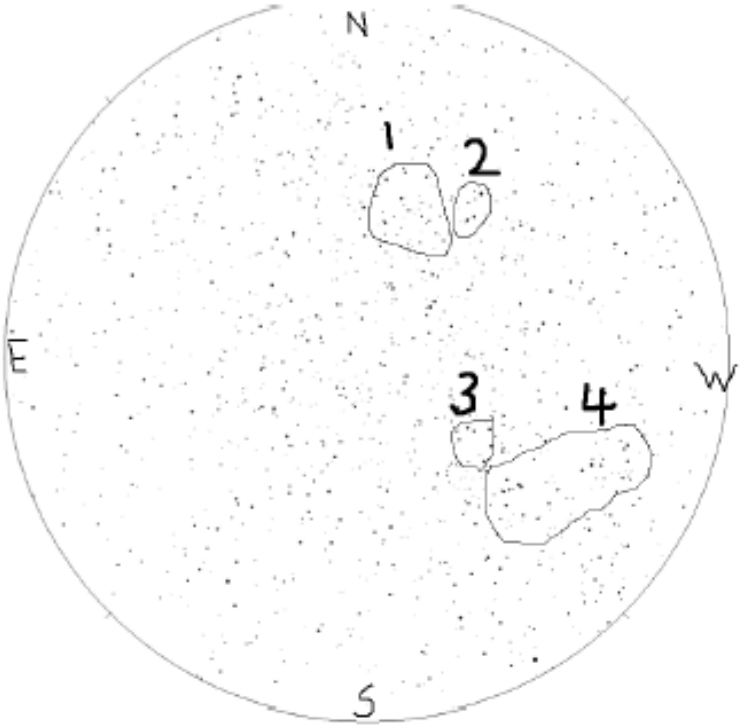
    (A) The star Polaris and constellation CETUS can be seen from London, England

    (B) The star Polaris and constellation CENTAURUS can be seen from Santiago, Chile

    (C) The star Betelgeuse and constellation OCTANS can be seen from Perlis, Malaysia

    (D) The star Polaris and constellation SCORPIUS can be seen from Cape Town, South Africa

55. In the star chart below are drawn the boundaries of four constellations. Which of the answer below shows the **COMPLETELY CORRECT MATCH** of the constellations with their names.



(A) 1 - PEGASUS
    2 - LYRA
    3 - SCORPIUS
    4 - LIBRA

(B) 1 - ORION
    2 - GEMINI
    3 - CASSIOPEIA
    4 - SCORPIUS

(C) 1 - CYGNUS
    2 - AQUILA
    3 - BOOTES
    4 - HERCULES

(D) 1 - CYGNUS
    2 - LYRA
    3 - SAGITTARIUS
    4 - SCORPIUS

56. The four pictures below show four astronomical objects in the Milky Way Galaxy. Which of the answer below is the **COMPLETELY CORRECT MATCH** of the astronomical objects and the constellations that they are located in.

Object 1

Object 2

Object 3

Object 4

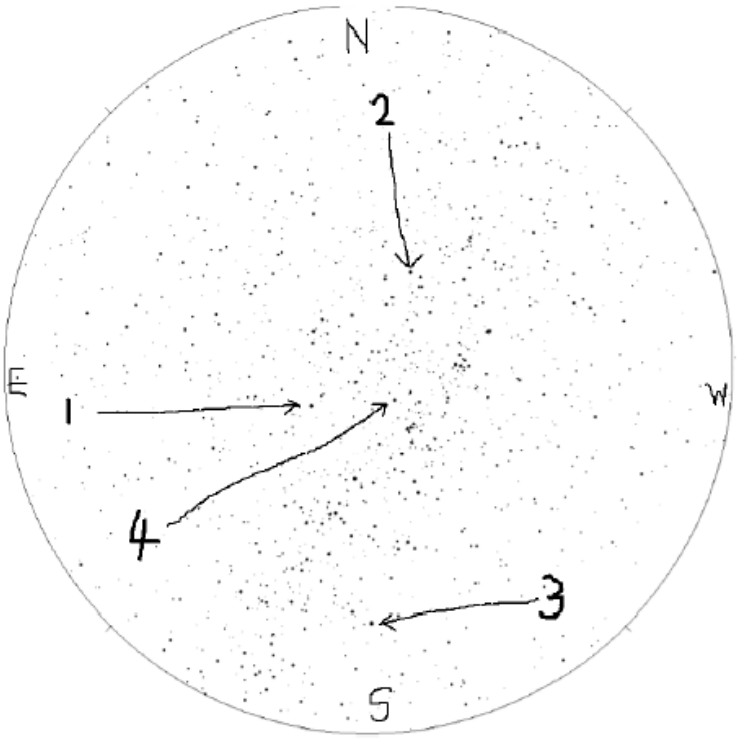
(A) Object 1 in TAURUS
Object 2 in BOOTES
Object 3 in URSA MAJOR
Object 4 in LYRA

(B) Object 1 in TAURUS
Object 2 in PEGASUS
Object 3 in PERSEUS
Object 4 in SCORPIUS

(C) Object 1 in ORION
Object 2 in LIBRA
Object 3 in COMA BERENICES
Object 4 in SAGITTARIUSE

(D) Object 1 in ORION
Object 2 in GEMINI
Object 3 in CANES VENATICI
Object 4 in HERCULES

57. In the star chart below are shown the four pointers pointing at four stars. Which of the answer below shows the **COMPLETELY CORRECT MATCH** of the pointers pointing to the stars.



(A) 1 - Procyon
2 - Capella
3 - Canopus
4 - Betelgeuse

(B) 1 - Regulus
2 - Castor
3 - Arcturus
4 - Merak

(C) 1 - Sirius
2 - Capella
3 - Canopus
4 - Betelgeuse

(D) 1 - Antares
2 - Sirius
3 - Aldebaran
4 - Canopus

58. Recently a member of the Astronomical Society of Penang visited an Asian country and captured in Picture A a night scene of a bridge. In Picture B is an enlarged picture of the scene showing the crescent Moon. From the inclination of the crescent Moon, it is possible to tell which location in Asia that the picture was taken. The picture was taken in:

Picture A

Picture B

(A) Hong Kong
(B) Singapore
(C) South Korea
(D) Vietnam

59. On a certain day, two groups of people are making new Moon sightings in two locations in Malaysia. The first group of people is conducting the new Moon sighting in Sheikh Tahir Astronomical Centre in Pantai Acheh in Penang. The second group of people is conducting the new Moon sighting in Al-Biruni Observatory in Putatan, Sabah. Assuming that the weather is clear in these two locations, give the correct reasons why there is a better chance to see the new Moon in one location as compared to that of the second location. Given that the distance from Pantai Acheh in Penang to Putatan in Sabah is $1,740$ kilometers.

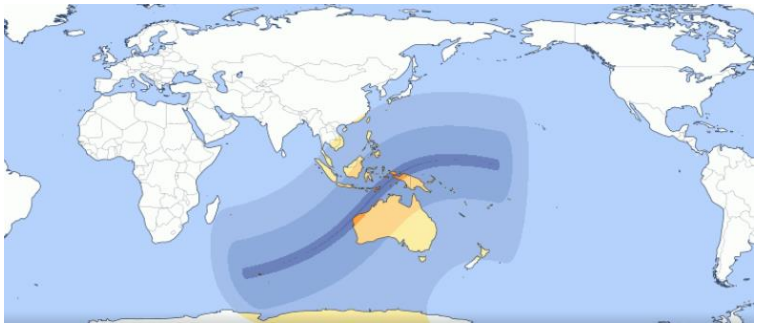
    (A) The new Moon will rise earlier as seen from Putatan and therefore from Putatan there is a better chance to see the new Moon

    (B) The new Moon will set later as seen from Pantai Acheh and therefore from Pantai Acheh there is a better chance to see the new Moon

    (C) When the new Moon is seen in Putatan, as seen from Pantai Acheh the curvature of the Earth will block the view of the new Moon. Therefore from Putatan there is a better chance to see the new Moon

    (D) The latitude of Pantai Acheh is 4.1^0 North and the latitude of Putatan is 6.0^0 North. Therefore from Pantai Acheh there is a better chance to see the new Moon

60. On 20 April 2023, a **Hybrid Solar Eclipse** will be visible in places located in the maps below. A group of Malaysian amateur astronomers will be travelling to the town of Exmouth in Western Australia to observe the eclipse. The Malaysians will be on the centre line of the eclipse (blue line) close to the town of Exmouth to observe the eclipse. Many interesting phenomena will occur from the beginning to the end of the eclipse. Which statement below is COMPLETELY CORRECT concerning the phenomena that will occur from the beginning to the end of the eclipse as observed from the centre line near to Exmouth.



Hybrid Solar Eclipse of 20 April 2023

Hybrid Solar Eclipse of 20 April 2023

Hybrid Solar Eclipse of 20 April 2023

Hybrid Solar Eclipse of 20 April 2023

(A) The Sun will rise in the East during the morning hours, the partial phase of the eclipse will then occur, the total solar eclipse will then last for 60 seconds followed the partial solar eclipse and the end of the whole eclipse. During the total solar eclipse phase, the sky will become completely dark and the stars and planets will become visible.

(B) The Sun will rise in the East during the morning hours, the partial phase of the eclipse will then occur for 23 minutes, the total solar eclipse will last for 12 minutes followed by the partial solar eclipse for another 23 minutes and the end of the whole eclipse. During the total solar eclipse phase, the sky will become completely dark and the stars and planets will become visible.

(C) The Sun will rise in the East during the morning hours, the total solar eclipse will then occur for 60 seconds, followed by the partial solar eclipse phase and the end of the whole eclipse. During the total solar eclipse phase, the sky will become completely dark and the Moon, stars and planets will become visible.

(D) The Sun will rise in the East during the morning hours, the partial solar eclipse will then occur followed by the total solar eclipse for 60 seconds and the end of the whole eclipse. During the total solar eclipse phase, the sky will become completely dark and the Moon, stars and planets will become visible.

END OF QUESTIONS