AstroChallenge 2018
Multiple Choice Questions
(Senior)

PLEASE READ THESE INSTRUCTIONS CAREFULLY

1. This paper consists of **20** 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. If you think there is more than one correct answer, choose the most correct answer.
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.

1. Consider the following planets and their orbital eccentricities.

Planet	Orbital Eccentricity
A	0.206
B	0.007
C	0.017
D	0.093
E	0.048

Which planet has the **most circular** orbit?

(A) Planet A.

(B) Planet B.

(C) Planet C.

(D) Planet D.

(E) Planet E.

2. Which of the following **best** characterises the movement of a star onto the horizontal branch of a HR diagram?

(A) The onset of helium burning after a helium flash.

(B) The onset of neon burning in an extremely massive star.

(C) The expansion of a low-mass star into a red giant.

(D) The sudden collapse of an iron core into a compact ball of neutrons.

(E) The sudden outpouring of X-rays from a newly formed accretion disk.

3. The following are some neolithic structures portraying the effects of astronomical alignment, as well as an archaeological relic that was thought to be previously used for astronomical purposes.

I. Khafre's pyramid in Egypt ($29^\circ\,59'$) was built about 4700 years ago with one of its sides aligned with the direction in which the star 3-Scorpii sets.

II. The neolithic burial chamber Maeshowe ($59^\circ\,00'$) was built about 5000 years ago so that the last rays of the setting sun on the winter solstice would travel down the long entrance tunnel to illuminate the interior of the tomb.

III. The Antikythera mechanism, thought to be built in 100–150 BC, predicted eclipses based on the Saros cycle.

Which of these will still work this year? Ignore any effects of erosion and rusting.

(A) II only.

(B) I and II only.

(C) I and III only.

(D) II and III only.

(E) I, II, and III.

4. Consider the following HR diagrams for different clusters of stars.

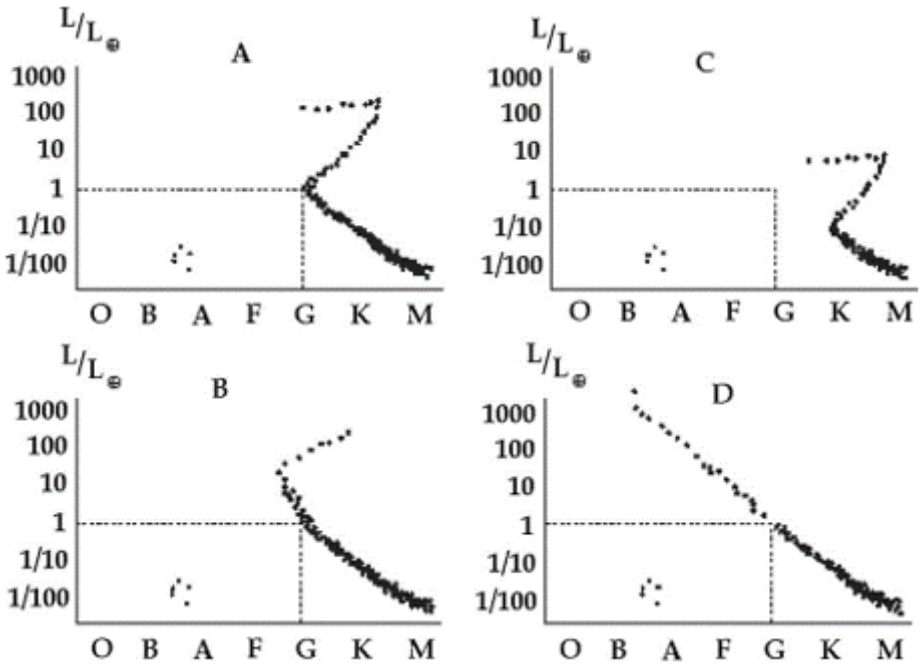

Figure 1: HR diagrams for several star clusters.

Consider the following statements.

I. Cluster D is the youngest.

II. Cluster A is probably about 10 billion years old.

III. The average temperature of the main sequence stars in cluster C is lower than the temperature of our Sun.

Which of the statements above is/are true?

(A) I only.

(B) I and II only.

(C) I and III only.

(D) II and III only.

(E) I, II, and III.

5. What is the theoretical maximum number of eclipses that can occur in a calendar year? Note that the length of a synodic month is 29.5 days, and that the length of an eclipse cycle is approximately 31 to 37 days.

(A) 5

(B) 6

(C) 7

(D) 8

(E) 9

Refer to the information below to answer Questions 6 and 7.

In a hypothetical star system, an exoplanet was discovered by the Singapore Space Agency (SSA) in the year 2050. This exoplanet, named Singa, was discovered through the transit method, whereby the brightness of the only main-sequence star, named Marie, drops by 0.845% every 25.35 years. The luminosity of Marie is thrice the luminosity of the Sun in our solar system. Coincidentally, the mass of Singa was determined to be equal to the mass of the Earth. Assume that Singa revolves around Marie in a circular orbit. Furthermore, assume that both Marie and Singa are perfectly spherical.

6. Let V_M and V_S be the volumes of Marie and Singa respectively. What is the value of $\frac{V_M}{V_S}$?

   (A) 8.34

   (B) 24.1

   (C) 118

   (D) 1290

   (E) 46200

7. What is the orbital angular momentum of Singa with respect to Marie?

   (A) 2.74×10^{35} kg m^2 s^{-1}.

   (B) 7.04×10^{35} kg m^2 s^{-1}.

   (C) 8.23×10^{35} kg m^2 s^{-1}.

   (D) 9.63×10^{35} kg m^2 s^{-1}.

   (E) 2.47×10^{36} kg m^2 s^{-1}.

8. Which of the following rotational/orbital/circular motions are anti-clockwise (rather than clockwise) when observed top-down with North of the ecliptic plane on top?

   I. Rotation of Venus about its own rotational axis.

   II. The circle traced by the North Celestial Pole due to precession of the Earth.

   III. The orbit of Uranus about the Sun.

   IV. The rotation of the Earth's Moon about its own rotational axis.

   Which of the above statements are correct?

   (Hint: Consider the direction of rotation of the protoplanetary disk.)

   (A) I and II only.

   (B) III and IV only.

   (C) I, II, and III only.

   (D) II, III, and IV only.

   (E) I, II, III, and IV.

9. Consider the following statements about general relativity.

   I. Earth orbits the Sun because the Earth and Sun are connected by "rope-like" set of invisible, subatomic particles.

   II. Different reference frames will measure time differently because they are experiencing the same 4D spacetime, but from different perspectives.

   III. Time runs faster in stronger gravitational fields.

   IV. Wormholes violate general relativity.

   Which of the statements above is/are true?

   (A) II only.

   (B) I and III only.

   (C) II and III only.

   (D) II, III, and IV only.

   (E) I, III, and IV only.

10. The following graph shows the visual magnitude of a variable star. The average absolute magnitude of the star is 0.75.

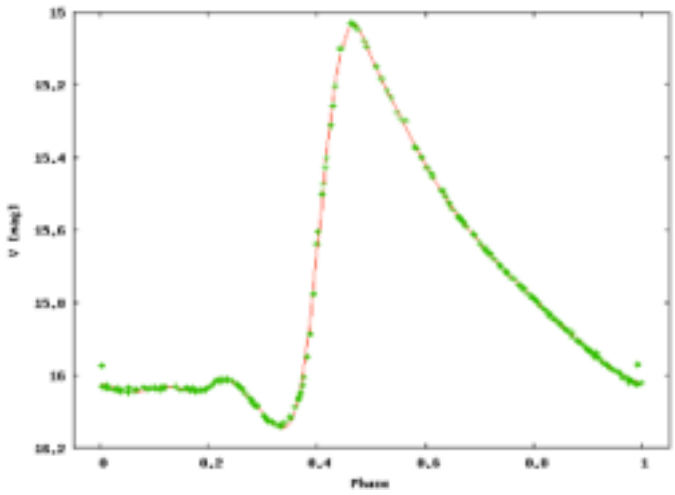

Figure 2: Visual magnitude of a variable star.

The variable star mentioned is a _____.

(A) T-Tauri variable with a distance of 2.5×10^3 pc.

(B) RR Lyrae variable with a distance of 9×10^3 pc.

(C) Algol variable with a distance of 1×10^4 pc.

(D) Mira variable with a distance of 2.3×10^4 pc.

(E) S Cepheid variable with a distance of 6.9×10^4 pc.

11. Consider the following statements regarding a Schwarzschild (non-rotating) black hole.

    I. If an object falls into a black hole, according to an observer infinitely far from the black hole, the object never crosses the event horizon.

    II. All black holes have a mass density greater than the density of the Earth. (Note: We define the density of a black hole as the event horizon density, i.e. the mass divided by the volume enclosed by its event horizon. Of course in reality, black holes do not have a well-defined density.)

    III. A black hole cannot emit any particle since everything that are trapped inside the event horizon can only move closer to the centre of the black hole and can never escape.

    Which of the above statements is/are correct?

    (A) I only.

    (B) II only.

    (C) I and II only.

    (D) I and III only.

    (E) II and III only.

12. Barnard's star is one of the fastest moving stars as seen from the Earth. It has a tangential velocity of $89.7\,\mathrm{km\ s^{-1}}$ and a radial velocity of $-108\,\mathrm{km\ s^{-1}}$ as seen from the Earth. It has a distance of $1.83\,\mathrm{pc}$ from the Earth.

    If its motion remains approximately constant, how long will it take for Barnard's star to reach its closest approach to the Sun?

    (Hint: Drawing a diagram of the situation will help.)

    (A) 7060 years.

    (B) 7970 years.

    (C) 8880 years.

    (D) 9790 years.

    (E) 10700 years.

13. Complete the following statement if it is true; otherwise pick Option (E).

    Emission nebulae are typically red because _____.

    (A) they surround young stars that emit red light

    (B) atmospheric extinction absorbs blue light from the nebula

    (C) hydrogen in these nebulae are excited and preferentially emit red light

    (D) dust in the nebula preferentially reflects red light, giving it a red appearance

    (E) This is false. Emission nebulae tend to be blue.

14. Consider the following statement in an astronomy magazine on an upcoming conjunction of Mars and Venus.

    Whenever Mars appears anywhere near Venus, it seems to get scared and fade.

    Is this statement true? Why?

    (A) It is true. A conjunction of Mars and Venus reminds us that love overcomes conflict.

    (B) It is false. Mars can be at peak brightness while near Venus.

    (C) It is true. Even though the brightness of Mars is constant, Venus is so bright that our eyes cannot adapt properly, causing Mars to "appear" dimmer during this period.

    (D) It is false. The astronomy magazine is in error.

    (E) It is true. Geometry dictates that Mars must be on the far side of its orbit in order to be at conjunction with Venus.

15. I observe that Star A and Star B have the same brightness in the same field of view. Which of the following statements (considered individually) provide sufficient information for me to definitively conclude that Star A has a lower luminosity than Star B?

    (A) Star B has a greater mass than Star A.

    (B) Star B is closer to us than Star A.

    (C) Star B has evolved onto the horizontal branch, while Star A is still on the main sequence.

    (D) Star B is bluer than Star A.

    (E) None of the statements above provide sufficient information individually.

16. The cosmic microwave background allows us to observe information about the early universe up to around 3.8×10^5 years after the Big Bang, after recombination (formation of electrically neutral hydrogen) has occurred. An astronomer proposes studying the following to obtain even earlier information of the universe.

    I. Gravitational wave background (stochastic background).

    II. Diffuse supernova neutrino background.

    III. Cosmic neutrino background.

    IV. The Hubble eXtreme deep field (i.e. even older galaxies in the Hubble ultra-deep field than have been previously studied).

    Which of the above might work?

    (A) I and II only.

    (B) I and III only.

    (C) III and IV only.

    (D) I, II, III, and IV.

    (E) None of the above methods would work.

17. Consider the following statements about Titan, Saturn's moon.

    (I) Titan and Earth are the only celestial bodies in the solar system that experience precipitation (i.e. condensation of any atmospheric vapour that falls under gravity, such as rain).

    (II) Titan and Earth are the only celestial bodies in the Solar System with an atmosphere of mostly nitrogen gas.

    (III) If Titan had life, they would likely utilise liquid hydrocarbons as a solvent for biochemical processes, as compared to water for life on Earth.

    (IV) Titan is likely to have volcanism in the form of cryo-volcanoes that spew water and ammonia, as compared to volcanoes that spew molten rock (lava) on Earth.

    Which of the above statements is/are definitely false?

    (A) I only.

    (B) IV only.

    (C) II and III only.

    (D) II and IV only.

    (E) None of the statements are definitely false.

18. Fermi's paradox is stated as follows.

    There is a lack of evidence of extra-terrestial life, despite high probability estimates for the existence of extra-terrestrial life.

    Which of the following is NOT a plausible reason that could account for Fermi's paradox?

    (A) Nearby alien lifeforms are either too primitive or too advanced for humans to detect with our technology.

    (B) The physical distances across galaxies and planets might be too great to warrant extensive interstellar travel as a feasible colonisation strategy for even advanced civilisations.

    (C) There is no evidence that complex biomolecules can form naturally from simple, inorganic molecules.

    (D) The biological factors allowing for the evolution of biologically complex and/or intelligent life involve occurrences with extremely low probabilities, which might only have been fulfilled on Earth thus far.

    (E) Intelligent lifeforms tend to destroy themselves and/or other such lifeforms.

19. Rank the following nebulae in order of increasing size.

- Ring Nebula (M57): A famous and colourful planetary nebula.
- Tarantula Nebula (30 Do): Emission nebula, starburst region in Large Magellanic Cloud.
- Crab Nebula (M1, once SN 1054): Supernova remnant of a recent supernova.
- Stingray Nebula (Hen 3-1357): Youngest known Planetary Nebula.
- Lagoon Nebula (M8): Emission nebula, with NGC 6530 (an open cluster) in its foreground.

(A) Ring < Tarantula < Crab < Stingray < Lagoon

(B) Crab < Ring < Lagoon < Stingray < Tarantula

(C) Ring < Stingray < Crab < Tarantula < Lagoon

(D) Crab < Ring < Stingray < Lagoon < Tarantula

(E) Stingray < Ring < Crab < Lagoon < Tarantula

20. Which of the following statements on galactic astronomy is correct?

(A) Hubble's tuning fork provides an accurate description of the evolution of galaxy formation.

(B) The galactic coordinate system uses the centre of the Milky Way as its origin.

(C) Active galactic nuclei (AGN) refer to the centres of certain galaxies that radiate with higher-than-expected luminosity and whose emission is atypical of starlight.

(D) The star-forming regions of galaxies are typically found near the core of the galaxy.

(E) The old population of globular clusters are largely found along the spiral arms of galaxies.

21. Which of the following statements is false?

(A) A spiral galaxy has both old and young stars.

(B) Globular clusters can contain millions of stars, but usually no gas or dust.

(C) The birth of stars is a battle between gravity and radiation pressure.

(D) You drop an indestructible probe with lights near a black hole and watch it fall in. The lights on the probe would appear to become bluer.

(E) You drop an indestructible probe with a clock near a black hole and watch it fall in. The clock would appear to stop when it reaches the event horizon.

Refer to Hong Kiat's observation plan below to answer Questions 22 to 25.

Object	**Constellation**	**RA**	**Declination**	**Apparent Brightness**	**Surface Brightness**	**Distance to object (kpc)**
M36 (Pinwheel Cluster)	Auriga	5h 36min	$+34° 08'$	6.00	10.74	1.30
M38 (Starfish Cluster)	Auriga	5h 28min	$+35° 51'$	6.40	12.02	1.30
M41	Canis Major	6h 46min	$-20° 46'$	4.50	12.19	0.71
M45 (Pleiades Cluster)	Taurus	3h 47min	$+24° 07'$	1.20	11.14	0.14
C92 (Eta Carinae Nebula)	Carinae	10h 44min	$-59° 53'$	1.00	11.13	2.00

22. Which of the following statements about these objects is the most accurate given the information provided above?

    (A) The Pinwheel Cluster has a greater maximum altitude in the night sky (i.e. approaches closer to the zenith) than M41.

    (B) M41 would never rise for astronomers at the South Pole.

    (C) The Pleiades Cluster would rise approximately two hours after M36.

    (D) All of the objects can be found within or along the Milky Way.

    (E) M36 is significantly brighter than the Pleiades Cluster.

23. In which order should one observe the objects listed in the above observation plan (from earliest to latest).

    (A) M45, M38, C92, M36, M41.

    (B) M41, M36, M38, M45, C92.

    (C) M45, M41, C92, M36, M38.

    (D) M45, M38, M36, M41, C92.

    (E) C92, M45, M41, M36, M38.

24. The rising time of M36 is _____h, and the setting time of M45 is _____h.

    (A) 1935; 2346

    (B) 2125; 2246

    (C) 0043; 0247

    (D) 1935; 0535

    (E) 0536; 0646

25. What was the local time on 9 December when the Local Sidereal Time was 0h 00min?

    (A) 0245h.

    (B) 0643h.

    (C) 1359h.

    (D) 1735h.

    (E) 1959h.

Using the following information, answer Questions 26 and 27.

It is known that a certain Seyfert galaxy, XHK1996, has an active galactic nucleus (AGN) so luminous that its core appears to be a star under telescope magnification. It was observed that the peak wavelength of the O III primary transition line of 5089 angstroms has been redshifted to 5007 angstroms.

26. How far does XHK1996 lie away from us?

    (A) 56 Mpc.

    (B) 68 Mpc.

    (C) 72 Mpc.

    (D) 86 Mpc.

    (E) 100 Mpc.

27. What is an appropriate upper bound to the diameter of the galactic nucleus, given that XHK1996 appears to be an unresolved star even when observed by the 3.0m Arcillas Brian Space Telescope?

    (Hint: You might find it helpful to recall that the visible spectrum lies between 390 nm to 700 nm.)

    (A) 11.30 pc.

    (B) 12.81 pc.

    (C) 16.45 pc.

    (D) 25.62 pc.

    (E) 32.74 pc.

28. What is happening inside a star while it is expanding into a sub-giant?

    (A) It is fusing helium into carbon in a shell outside the core.

    (B) It is fusing helium into carbon in the core.

    (C) It is fusing hydrogen into helium in the core.

    (D) It is fusing hydrogen into helium in a shell outside the core.

    (E) It is not fusing any element, it is contracting and heating up.

29. The following graph shows the rotation curve of the Milky Way.

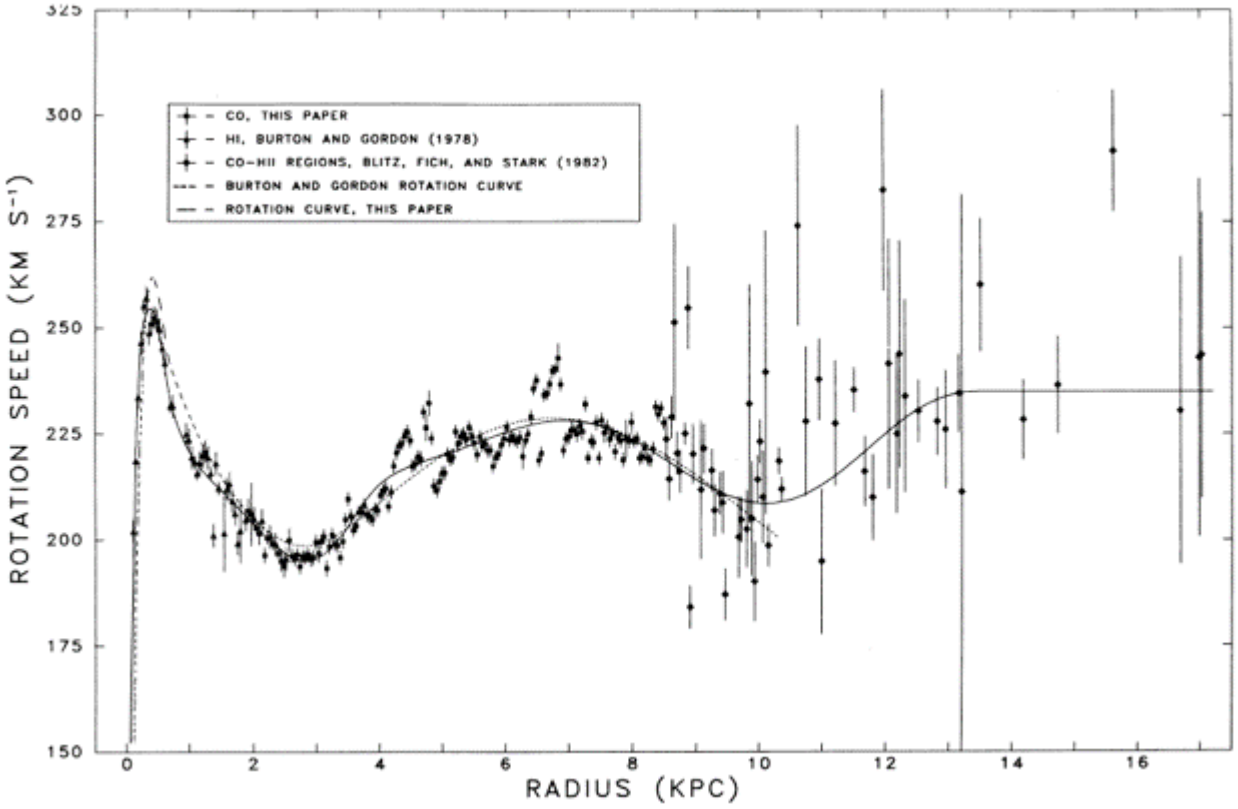

Figure 3: Rotation curve of the Milky Way.

Which of the following statements about the Milky Way is inaccurate?

(A) The rotation curve provides supporting evidence that there exists non-luminous matter, dark matter residing beyond 12 kpc.

(B) Our Solar System has an approximate rotation speed of 225 km s^{-1} about the galactic core.

(C) Our Solar System lies about 7 to 8 Mpc away from the centre of the galactic core.

(D) The curve is fitted using data from various sources.

(E) Before introducing dark matter, models derived from purely General Relativity and Newtonian gravity are unable to adequately account for the behaviour at distances beyond 10 kpc.

Using the following information, answer questions 30 to 32.

It is the winter solstice, 22 December 2017. The sun is lowest in altitude at maximum during the winter solstice (at local noon), and the angle of tilt of the Earth is 23.5° from the ecliptic.

30. What is the local sidereal time?

    (A) 0000h.

    (B) 0600h.

    (C) 1200h.

    (D) 1800h.

    (E) There is insufficient information to determine the local sidereal time.

31. What is the sun's approximate declination and altitude in the sky when it is along the local meridian?

    (A) 23.5°; 23.5°.

    (B) 23.5°; 65.5°.

    (C) −23.5°; 23.5°.

    (D) −23.5°; 65.5°.

    (E) There is insufficient information to determine the approximate declination and altitude.

32. Consider the following objects.

Object	**Right ascension**	**Declination**
M8 (Lagoon Nebula)	18h 03min	$-24^\circ\,22'$
M57 (Ring Nebula)	18h 53min	$+33^\circ\,01'$
NGC 6334 (Cat's Paw Nebula, in Scorpius)	17h 20min	$-36^\circ\,06'$
C92 (Eta Carinae Nebula, in Carina)	10h 44min	$-59^\circ\,53'$

    During the said winter solstice, which of the above objects cannot be observed anywhere on earth?

    (A) M8, NGC 6334.

    (B) M8, M57, C92.

    (C) M8, NGC 6334, C92.

    (D) M57, NGC 6334, C92.

    (E) There is insufficient information to determine.

33. The four-arm model of the Milky Way is a popular candidate for the precise shape of the galaxy we live in, and is supported by several studies. One of these involve high-mass stars. What is a main reason for using such stars?

    (A) High mass stars are easier to detect due to their brightness.

    (B) High mass stars generally form in gas clouds of lower density tracing the edges of the arms.

    (C) High mass stars form from gravity waves passing through the arms.

    (D) High mass stars are bound closer together due to higher gravitational forces between such stars.

    (E) High mass stars do not have the time to migrate.

34. You have a telescope of focal specifications 6-inch f/20. You wish to point your telescope at Sirius (declination $16^\circ\,42'\,58''$) from Singapore and introduce your friend to this system. You need Sirius to stay in the FOV for at least half a minute. Assume the telescope is completely stationary.

    Which of the following eyepieces provides the highest zoom satisfying the needed duration for Sirius to remain in the FOV?

    (A) Eyepiece A: 20 mm focal length, 50° AFOV.

    (B) Eyepiece B: 15 mm focal length, 50° AFOV.

    (C) Eyepiece C: 10 mm focal length, 56° AFOV.

    (D) Eyepiece D: 6 mm focal length, 56° AFOV.

    (E) Eyepiece E: 4 mm focal length, 60° AFOV.

35. The Big Bang model is commonly accepted today as the model describing the universe and its formation. The main difference between the Big Bang model and the Steady State model (another postulated model in the 20^{th} century) is that the Steady State model postulates that the density of the expanding universe remains constant due to continuous formation of matter. Under this hypothesis, the cosmic microwave background radiation is caused by the scattering by galactic dust. Which of the following statements is true?

    (A) The Steady State model does not account for the observed homogeneity of the observable universe.

    (B) The Steady State model does not account for the observation that radio sources are primarily found at great distances.

    (C) The Steady State model can account for the observed uniform distribution of cosmic microwave background radiation.

    (D) The Steady State model accounts for the presence of radio sources in the star clusters orbiting the Milky Way galaxy.

    (E) Both the Big Bang model and the Steady State model account for the observed polarisation of the cosmic microwave background radiation.

36. If the average mass density of the Universe exceeded the critical density, which of the following statements would be true?

(A) The curvature of space would be negative.

(B) The mass density will eventually decrease to be equal to the critical density.

(C) The Universe would eventually re-collapse.

(D) The sum of angles of a (very large) triangle would be less than 180°.

(E) The present Hubble expansion would slow down but never come to a stop.

37. Which of the following conditions are required for a solar eclipse to occur?

(A) The phase of the Moon can be new or full, and the nodes of the Moon's orbit must be nearly aligned with the Earth and the Sun.

(B) The phase of the moon must be full, and the Moon's orbital plane must lie in the ecliptic.

(C) The phase of the Moon must be new, and the nodes of the Moon's orbit must be nearly aligned with the Earth and the Sun.

(D) The phase of the moon must be new, and the Moon's orbital plane must lie in the ecliptic.

(E) The phase of the Moon must be full, and the nodes of the Moon's orbit must be nearly aligned with the Earth and the Sun.

38. Consider the following properties of a planet with seasons.

I. Axial tilt.

II. Eccentricity.

III. Semi-major axis.

Which of the above determine(s) the length of the planet's seasons?

(A) I only.

(B) II only.

(C) I and II only.

(D) I and III only.

(E) II and III only.

39. Which of the following statements regarding detection methods for exoplanets is false?

(A) Gravitational microlensing events of exoplanets almost never repeats.

(B) The Doppler method can be used to determine an exoplanet's minimum mass.

(C) The transit method favours the detection of exoplanets with similar mass to Earth.

(D) Few exoplanets have been detected by ground-based astrometry due to atmospheric distortion.

(E) Unlike other methods, direct imaging is more effective for exoplanets with face-on orbits rather than those with edge-on orbits.

40. The stars that make up the Winter Hexagon come from the constellations Auriga, Taurus, Orion, Canis Major, Canis Minor, and Gemini. What other constellation can be found within the Winter Hexagon?

    (A) Lepus.

    (B) Cancer.

    (C) Lynx.

    (D) Monoceros.

    (E) Hydra.

41. Which of the following statements about the Milky Way is false?

    (A) While we believe the Milky Way is a spiral galaxy, it is extremely difficult to determine the exact shape of the Milky Way as we are located within it.

    (B) All of the stars that we can see with the naked eye belong to the Milky Way.

    (C) A supermassive black hole is believed to exist at the centre of the Milky Way.

    (D) From our perspective, the Galactic Centre appears to lie within the constellation of Scorpius.

    (E) From the Northern Hemisphere, the core of the Milky Way is best seen in summer.

42. It is local midnight, and these are the following constellations you can observe when you look at the night sky.

    - Caelum (southern constellation) near the zenith.
    - Regulus.
    - Auriga approximately due North.

    Given that the Sun lies in Leo from July to August, which season are you currently experiencing?

    (A) Winter.

    (B) Spring.

    (C) Summer.

    (D) Fall.

    (E) There is insufficient information to determine the season.

43. If the Earth suddenly lost all of its orbital velocity, how long would it take the Earth to fall into the Sun?

    (A) 35 days.

    (B) 45 days.

    (C) 55 days.

    (D) 65 days.

    (E) 75 days.

44. For a reference planet A and another planet B in the same system, the synodic period S of B is related to its sidereal period P and the sidereal period $P_\oplus$ of A by the following formula.

$$\frac{1}{S} = \begin{cases} \frac{1}{P} - \frac{1}{P_\oplus}, & B \text{ is an inferior planet,} \\ \frac{1}{P_\oplus} - \frac{1}{P}, & B \text{ is a superior planet.} \end{cases}$$

Let the period of orbit of a reference planet around its star in a star system be S_p. Which of the following statements about the synodic period of an inferior planet S_i, and the synodic period of a superior planet S_s, is true for **all** star systems with inferior and superior planets?

(A) $S_i \neq S_s$.

(B) $S_i > S_s$.

(C) $S_s > S_i$.

(D) As the distance of an inferior planet from the star tends towards zero (i.e goes very close to the star), S_i tends towards S_p.

(E) As the distance of a superior planet from the star tends towards infinity (i.e goes very far away from the star), S_s tends towards S_p.

45. Astronomers have reported that the centre of the Milky Way galaxy smells like raspberries and tastes like rum. This is due to the presence of certain organic molecules formed via abiogenesis. Consider the following statements regarding the "smell" of the centre of the Milky Way galaxy.

I. Abiogenesis suggests that these organic molecules are formed from inorganic molecules and matter.

II. The presence of these organic molecules indicates that the presence of extra-terrestrial intelligence near the centre of the Milky Way galaxy.

III. The fruity smell of raspberries can possibly be attributed to an ester (e.g. ethyl formate).

Which of the above statements is/are true?

(A) I only.

(B) I and II only.

(C) I and III only.

(D) II and III only.

(E) I, II, and III.

46. Consider the following statements about the categorisation of some of the more prominent stars in the night sky according to their asterisms.

I. The lid of the teapot asterism is formed by the three stars in the constellation of Sagittarius λ Sgr (Kaus Borealis), δ Sgr (Kaus Media), and ϕ Sgr.

II. The Northern Cross is essentially a cross formed by two lines, one line joining α Crucis (Acrux) and γ Crucis (Gacrux), and another line joining β Crucis (Mimosa) and δ Crucis.

III. The Winter Triangle is a triangle formed by Sirius, Betelgeuse and Procyon.

IV. The Summer Triangle is a triangle formed by Arcturus, Regulus and Spica.

Which of the statements above are true?

(A) I and III only.

(B) II and III only.

(C) I, II, and IV only.

(D) I, III, and IV only.

(E) II, III, and IV only.

47. The phantom time hypothesis is a historical conspiracy theory asserted by Heribert Illig. First published in 1991, the hypothesis proposes a conspiracy by the Holy Roman Emperor Otto III, Pope Sylvester II, and possibly the Byzantine Emperor Constantine VII, to fabricate the Anno Domini dating system retrospectively, so that fast-forwarding the date placed them at the special year of AD 1000, and to rewrite history to legitimise Otto's claim to the Holy Roman Empire.

Heribert argued that there is a phantom time of X years before AD 1000. This is because when the Gregorian calendar was introduced in AD 1582, relative the date of effect of the Julian calendar 45 BC, a certain number of days should be subtracted to be converted from the Julian calendar to the Gregorian calendar. However, the astronomers and mathematicians working for the pope then found that the adjustment only needs to be 10 days.

Note that the difference between a Julian year and a Gregorian year is 11 minutes. What is the approximate length of the period of "phantom time" (missing time) hypothesised by Heribert in this conspiracy theory?

(A) 150 years.

(B) 300 years.

(C) 450 years.

(D) 600 years.

(E) 750 years.

48. The "full cold moon" happens on the eve of Christmas (night of 24 December). This phenomenon can be observed _____.

(A) from everywhere on Earth

(B) from the North pole

(C) from the South pole

(D) neither from the North nor South pole

(E) only from the North pole, and nowhere else

49. Equinoxes happen twice a year, at spring (21 March) and autumn (22 September). Consider the following statements.

I. At the equinoxes, the sun rises exactly due east.

II. The sun passes through the zenith of all observers at equinox.

III. At the equinoxes, the geometric centre of the Sun is above the horizon for exactly half a day, ignoring atmospheric refraction and the change in the Sun's declination in a single day.

IV. The autumnal equinox happens when the right ascension of the Sun is 0h 00min.

From the Northern Hemisphere, which of the above statements are wrong?

(A) I and II only.

(B) I and III only.

(C) II and III only.

(D) II and IV only.

(E) I, II, and III only.

50. Which of the following shows an astronomically correct crescent moon in context of Singapore, i.e from an observer from Singapore viewing the moon as it is seen just above the west horizon?

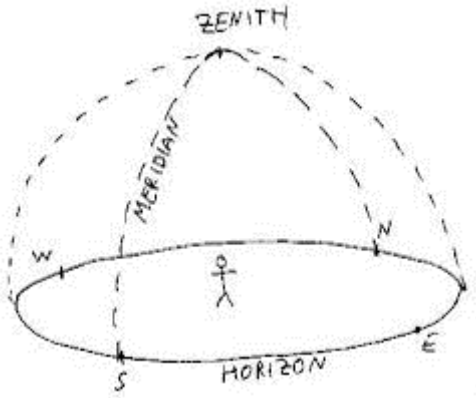

Figure 4: Visual representation of observer and horizon.

(A) Upright Singapore Flag:

(B) Laterally Inverted Singapore Flag:

(C) Upright Singapore Coat of Arms:

(D) Inverted Singapore Coat of Arms:

(E) None of the above.