



6th National Astronomy Olympiad 2019

January 26, 2019



F.M.: 90

Symbol No.:

Duration: 2 Hours

Category: Senior

Note: Please read carefully before you proceed to answer the questions:

- This question paper has objective and subjective section.
- **For objective Section:** Please tick one of the best options available. If more than one options are marked, such answers will not be considered for evaluation.
- **For subjective question:** Please give your answer as creative as possible. Please do your best to include as many steps as necessary.

OBJECTIVE SECTION

1. What is the approximate time of sunrise for an observer located in Indonesia (close to the Equator) on March 21st?
 - a. 7 am
 - b. 6 am
 - c. 5 am
 - d. 8 am
2. The current flowing through a wire is 3 A. Find the number of electrons that pass through the wire in 3 seconds.
 - a. 5.625×10^{19} electrons
 - b. 1.875×10^{19} electrons
 - c. 6.25×10^{18} electrons
 - d. 6.25×10^{19} electrons
3. A car moves from Pokhara to Kathmandu with an average speed of 40 km/hr. It then moves back from Pokhara to Kathmandu at an average speed of 60 km/hr. What is the average speed of the car for the entirety of its trip?
 - a. 47 km/hr
 - b. 48 km/hr
 - c. 49 km/hr
 - d. 50 km/hr
4. The Moon rises almost 2 hours before the Sun has set on a particular day. Estimate the Moon's phase.
 - a. Full Moon
 - b. Waxing Gibbous
 - c. Waning Crescent
 - d. First Quarter
5. If the Sun is located in the constellation of Capricorn, determine the season in the Southern Hemisphere.
 - a. Autumn
 - b. Winter
 - c. Summer
 - d. Spring
6. The focal length as measured using monochromatic red light of a convex lens is denoted A. The focal length as measured using monochromatic blue light of a convex lens is denoted B. Then
 - a. $B < A$
 - b. $B = A$
 - c. $B > A$
 - d. $B + A = \text{constant for all lenses}$
7. Hubble-Lemaitre's law is universally known. What is one *consequence* of this law?
 - a. The existence of Dark Matter
 - b. The existence of Dark Energy
 - c. Most galaxies are receding away from the Milky Way, with increased speed of recession for galaxies further away
 - d. Distant galaxies have red-shifts
8. Estimate the orbital period of a hypothetical planet that is in a circular orbit 50 times as distant from the Sun than the Earth.
 - a. 360 days
 - b. 360 years
 - c. 354 years
 - d. 354 days



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9. An Olympiad student fails to get a medal. The angry team leader launches him into a rocket far into space and then throws him out. The student just grazes the upper edge of the atmosphere during his trajectory back towards the Earth. He will:

- a. go around the Earth
- b. crash on the Moon
- c. be lost in space
- d. return to Olympiad venue

10. If v is the escape velocity of a given satellite, then its orbital velocity will be:

- a. $v^{(1/2)}$
- b. $2^{(1/2)} \times v$
- c. v
- d. $v/2^{(1/2)}$

11. If the Earth is assumed to be a homogeneous sphere and its radius is doubled, the time of rotation of the Earth will:

- a. remain unchanged
- b. double
- c. halve
- d. increase four-fold

12. The perihelion of a comet in orbit around the Sun is 0.1 AU and the aphelion of the same comet is 1.9 AU. What is the time of revolution for this comet?

- a. 11.5 days
- b. 2.62 years
- c. 1 year
- d. 2.83 years

13. The star Sirius is the brightest star in the constellation of Canis Major. It has a surface temperature of 9940 K and a radius that is 1.7 times that of the Sun. If the surface temperature of the Sun is 6000 K, estimate the ratio of the Luminosity of Sirius to the Luminosity of the Sun.

- a. 0.046
- b. 21.8
- c. 2.82
- d. 4.81

14. The orbit of a planet can be generalized by the equation $x^2/25 + y^2/16 = 1$, where 25 and 16 are in units of AU². What is the eccentricity of the planet's orbit?

- a. 0.8
- b. 0.2
- c. 0.6
- d. 0.4

15. Polaris has an altitude of 60 degrees in the sky. What is the latitude of the observer's location?

- a. 30 N
- b. 60 S
- c. 30 S
- d. 60 N

16. Find the redshift of a galaxy which emits in the Hydrogen-alpha line at 700nm. (The H-alpha line in a laboratory is 656.28 nm)

- a. 0.067
- b. 0.938
- c. 0.063
- d. 0

17. Let us imagine a situation where the maximum angular size of the full moon is 0.5 degrees and the minimum angular size of the sun is 0.6 degrees. Which of these phenomena would cease to occur?

- a. Total Solar eclipses
- b. Lunar Eclipses
- c. Solar eclipses
- d. Aurorae

18. In the Hertzsprung-Russell diagram, what stars occupy the top right-hand corner?

- a. Main Sequence stars
- b. Red Dwarfs
- c. White Dwarfs
- d. Red Giants

19. The magnitude scale for stars in astronomy is a logarithmic scale: $m_1 - m_2 = -2.5 \log (F_1/F_2)$ where F_1 is the flux of star 1, F_2 is the flux of star 2, whereas m_1 is the magnitude of star 1 and m_2 is the magnitude of star 2. If star 1 has a magnitude of 1, and star 2 has a magnitude of 2, which star has greater flux and by what factor?

- a. Star 1 by a factor of 10
- b. Star 1 by a factor of 2.51
- c. Star 2 by a factor of 10
- d. Star 2 by a factor of 2.51



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20. In a survey of the properties of galaxies, a total of 30 galaxies were sampled and their distances were noted. It was found that most of the galaxies occupied the same cluster, but a small number were found to be farther away than the cluster by a significant amount. Which of these quantities would give us a reasonable estimate for the distance to the cluster?

- a. Median
- b. Mean
- c. Mode
- d. Standard deviation

21. The Voyager 1 spacecraft is in a trajectory that will allow it to escape the gravitational attraction of the sun. It is known that the speed at which Voyager 1 is currently receding from the Sun is greater than the escape velocity at that point. Which conic section does the path of Voyager 1 sketch?

- a. Ellipse
- b. Parabola
- c. Circle
- d. Hyperbola

22. Which of the following is a consequence of the particulate nature of light?

- a. Interference
- b. Diffraction
- c. Reflection
- d. Photoelectric effect

23. The acceleration due to gravity on the surface of a planet is denoted by g . If the density of the planet is doubled, what is the new acceleration due to gravity?

- a. $0.5g$
- b. g
- c. $2g$
- d. $4g$

24. If the sun rises at 6 am on a given day in Dhulikhel (27.6 degrees North, 85.5 degrees East), what is a reasonable estimate for the time of sunrise in Dhangadhi (28.7 degrees North, 80.6 degrees East)?

- a. 5:40 am
- b. 6:20 am
- c. 6:05 am
- d. 5:55 am

25. What is the angular velocity of the Earth's rotation?

- a. $7.3 \times 10^{-5} \text{ rad s}^{-1}$
- b. $3.6 \times 10^{-5} \text{ rad s}^{-1}$
- c. $3.6 \text{ arcsecs s}^{-1}$
- d. $3.6 \text{ degrees s}^{-1}$

26. Which is the most distant object that can be seen with the naked eye?

- a. Orion Nebula
- b. Small Magellanic Cloud
- c. Large Magellanic Cloud
- d. Andromeda Galaxy

27. If a blue star replaced the Sun, which of the following is a likely consequence?

- a. The Earth becomes far too cold to support life
- b. Mercury is in the habitable zone
- c. There is no change on the Earth
- d. The Earth becomes far too hot to support life

28. Which of the following statements is false?

- a. Jupiter is about 300 times more massive than the Earth.
- b. The center of mass of the Solar System always lies inside the Sun.
- c. Ganymede is the largest moon in our Solar System.
- d. Titan is a moon of Saturn.

29. Which country recently landed a probe on the far side of the moon?

- a. Russia
- b. China
- c. India
- d. USA

30. What is the focal length of the objective of a telescope if its magnification is 20X when fitted with a lens having focal length 2mm?

- a. 40mm
- b. 10mm
- c. 20mm
- d. 0.1mm



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SUBJECTIVE SECTION

Note: Please use the answer-sheet provided to answer the following question. Please do not forget to write question no including sub-section. Also don't forget to write page number in each page.

1. Answer the following questions:

[10]

- The crater Copernicus is about 93 km in diameter and is located on the surface of the Moon. What is the minimum diameter of the objective lens of a telescope required to resolve this crater in the visible spectrum? (Earth-Moon distance is 3.84×10^5 km) (5)
- State Newton's Third Law of Motion in its complete form. (2)
- Derive the expression for escape velocity. (3)

2. The values of distance to a galaxy are determined using several different methods.

Method	Distance/ kpc
1	21.2
2	20.5
3	23.4
4	22.0
5	21.5
6	24.2
7	21.3
8	20.1

- Which method appears to be the least accurate? (1)
- Obtain an estimate for the actual distance to the galaxy. (3)
- Obtain an estimate for the uncertainty in the distance to the galaxy by calculating the standard deviation of the observations. (4)
- Quote your final answer for the distance to the galaxy in an appropriate form with units. (2)

3. Synodic periods are important in astronomy. One of the reasons why is because they allow us to determine the times of oppositions for various planets. In this question, we shall be deriving a time for the next opposition of Mars. We shall assume the orbits of Mars and Earth to be circular. Time period of Mars' orbit = 687 days, time period of Earth's orbit = 365 days [10]

- Derive an expression for the synodic time of Mars as seen from the surface of the Earth. Hint: Synodic time is defined as the time taken for an object to return to the same position in the sky. The difference in angle subtended at the centre of orbit by the two objects will be 360 degrees for the synodic period. (6)
- If an opposition of Mars occurred on 21st August 1991, determine when the next opposition occurred. (4)