

**THEORETICAL QUESTIONS**

1. A newly discovered moon has a mass of  $5 \times 10^{20}$  kg and a radius of 1,500 km. If a probe is launched from its surface, what is the minimum initial velocity it needs to completely escape the moon's gravity?  
  
(A) 165 m/s  
(B) 211 m/s  
(C) 225 m/s  
(D) 334 m/s
2. Star A has a surface temperature of 5,500 Kelvin, while Star B has a surface temperature of 3,000 Kelvin. If Star A emits 10 times more energy per second than Star B, how many times more luminous is Star A compared to Star B?  
  
(A) 2.5 times  
(B) 9.8 times  
(C) 10.4 times  
(D) 11.2 times
3. The Hubble Space Telescope orbits Earth at a certain distance. You wish to design a new telescope to study a distant galaxy. If this new telescope requires the same orbital period around Earth as the Hubble Space Telescope, how far from Earth should it be positioned?  
  
(A) Closer to Earth than the Hubble Space Telescope  
(B) Farther from Earth than the Hubble Space Telescope  
(C) At the same distance from Earth as the Hubble Space Telescope  
(D) At the Moon's distance from Earth

4. A spacecraft is orbiting a planet at a specific altitude. If the spacecraft's orbital period is doubled, what happens to its distance from the planet's center?
- (A) The distance increases by a factor of  $2^{3/2}$
  - (B) The distance increases by a factor of  $2^{2/3}$
  - (C) The distance increases by a factor of 2
  - (D) The distance remains the same
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  $48\text{ms}^{-2}$  and the asteroid accelerates  $5\text{ms}^{-2}$  in the opposite direction. How much heavier is the asteroid compared to the space probe?
- (A) 0.104
  - (B) 0.050
  - (C) 0.020
  - (D) 3.360
6. A star system has two planets, A and B. Planet A orbits the star twice as fast as Planet B. If the two planets are currently aligned in a straight line with the star, how long will it take for them to align again in the same manner?
- (A) One orbital period of Planet A
  - (B) One orbital period of Planet B
  - (C) Two orbital periods of Planet A
  - (D) Two orbital periods of Planet B
7. You are observing an inferior planet in your solar system. When it appears at its greatest western elongation, how far is it from you if your planet is 1.8 AU from the star and the inferior planet is 0.5 AU from the star?  
(Assume circular and coplanar orbits)
- (A) 1.2 AU
  - (B) 1.7 AU
  - (C) 0.8 AU
  - (D) 2.1 AU
-

8. A comet has an orbital period of 165 Earth years. What is its average distance from the Sun in astronomical units (AU)?  
(Assume Earth's orbital period is 1 year and its average distance from the Sun is 1 AU.)
- (A) 50 AU  
(B) 6 AU  
(C) 8 AU  
(D) 80 AU
9. If  $x = 3$ ,  $y = 2$  and  $z = x^2 + 2y - 3xz$ , then what is the value of  $z$ ? (round off to the nearest whole number)
- (A) 9  
(B) 7  
(C) 2  
(D) 1
10. Consider two vectors;  $a = 2i+3j$  and  $b = 4i-yj$ . What is the value of  $y$  if  $a+b = 6i-2j$ ?
- (A) 1  
(B) 2  
(C) 3  
(D) 5
11. Simplify:  $\frac{x^2 - 5x + 6}{x - 2}$
- (A)  $(x - 3)$   
(B)  $(x + 3)$   
(C)  $(x - 2)$   
(D)  $(x + 2)^2$
-

12. Two arbitrary stars, Alpha and Beta, originate from the same collapsing gas cloud. Both stars are propelled away from their birth place by the stellar winds of nearby newborn stars. Alpha attains a velocity of 100 kilometers per second in 1 million years, while Beta requires 2 million years to reach the same speed. Assuming constant acceleration for both stars, how does the net force acting on Alpha compare to that acting on Beta?
- (A) The net force on Alpha is twice as large as that on Beta
  - (B) The net force on Alpha is half as large as that on Beta
  - (C) The net force Alpha is equal to that on Beta
  - (D) The relationship between the net forces cannot be determined from the given information
13. Which of the following is an everyday application of the Stefan-Boltzmann Law?
- (A) Calculating the power output of a car engine
  - (B) Designing energy-efficient light bulbs
  - (C) Predicting the weather
  - (D) Determining the age of a fossil
14. You are designing a telescope specifically for studying binary star systems. Which of the following features would be MOST important?
- (A) A large aperture to gather maximum light
  - (B) A wide field of view to capture the entire system
  - (C) High resolution to distinguish between the two stars
  - (D) A long focal length for maximum magnification

15. NASA's Apollo missions brought back numerous Moon rocks from 1969 to 1972. By analyzing these rocks, scientists have developed theories about the Moon's origin. Which of the following statements regarding the Moon's formation is generally accepted as TRUE?
- (A) The Moon was captured by Earth's gravity
  - (B) The Moon formed from a giant impact between Earth and a Mars-sized object
  - (C) The Moon and Earth formed simultaneously from the same protoplanetary disk
  - (D) The Moon was ejected from Earth early in its history
16. In our Solar System, the four giant gas planets (Jupiter, Saturn, Uranus, and Neptune) possess rings, while the terrestrial planets (Mercury, Venus, Earth, and Mars) lack prominent rings. What is the most likely explanation for this difference?
- (A) The gravitational influence of the giant gas planets is stronger, allowing them to capture and maintain rings
  - (B) The terrestrial planets are too small to have captured ring material
  - (C) The strong solar wind near the terrestrial planets prevents ring formation
  - (D) The terrestrial planets have a higher density of atmospheres, which would disrupt any ring system
17. Which of the following celestial bodies is considered the most volcanically active in our Solar System?
- (A) Saturn
  - (B) Mars
  - (C) Ganymede
  - (D) Io
18. According to the International Astronomical Union (IAU), which of the following is NOT a requirement for a celestial body to be classified as a planet?
- (A) Orbits the Sun
  - (B) Has at least one moon
  - (C) Has sufficient mass to be nearly round
  - (D) Has cleared the neighborhood around its orbit
-

19. Which of the following phenomena is primarily caused by the gravitational interaction between the Earth and the Moon?
- (A) Earthquakes
  - (B) Hurricanes
  - (C) Tides
  - (D) Seasons
20. The International Space Station (ISS) maintains a near-circular orbit at an altitude of approximately 400 kilometers above Earth's surface. Considering the Earth's radius and the ISS's orbital velocity, calculate the approximate orbital period of the ISS.
- (A) 60 minutes
  - (B) 90 minutes
  - (C) 120 minutes
  - (D) 160 minutes
21. When we double a telescope's aperture radius, we can observe objects which are four times
- (A) Further
  - (B) Fainter
  - (C) Smaller
  - (D) Colder
22. An object in the night sky passing through a convex lens with a focal length of  $f$  will have its image focused at a distance of \_\_\_\_\_ away from the lens.
- (A)  $0.5f$
  - (B)  $f$
  - (C)  $2f$
  - (D)  $\infty$
-

23. In a science laboratory, a light ray is emitted into a block of fused quartz with refractive index,  $n = 1.46$  at an incident angle of  $30^\circ$ . What is the angle of refraction of the light ray?
- (A)  $0.3^\circ$
  - (B)  $20.0^\circ$
  - (C)  $30.0^\circ$
  - (D)  $46.9^\circ$
24. Which of the following about using a secondary mirror in a reflecting telescope is FALSE?
- (A) The placement of the secondary mirror will significantly obstruct the amount of light collected by the primary mirror.
  - (B) The secondary mirror may absorb some light reflected from the primary mirror.
  - (C) The secondary mirror can be either convex or concave, depending on the type of reflector.
  - (D) The secondary mirror is needed in a reflecting telescope for observations to be made through an eyepiece.
25. The Milky Way galaxy contains about 100 \_\_\_\_\_ stars.
- (A) Thousand
  - (B) Million
  - (C) Billion
  - (D) Trillion
26. The parallactic angle of a star is defined to be half of its apparent shift relative to the background as we move from one side of Earth's orbit to the other, a distance which gives a baseline of
- (A) 2 lightyears (ly)
  - (B) 2 astronomical units (AU)
  - (C) 2 arcseconds (")
  - (D) 2 parallaxes in arcseconds (parsec)
-

27. After the Sun, the next closest star to the Earth is \_\_\_\_\_, which is 4.3 ly away.
- (A) Barnard's star
  - (B) Proxima Centauri
  - (C) Sirius
  - (D) Venus
28. To estimate the \_\_\_\_\_ of a star, we just need to measure the Doppler shift of light waves radiated from the star.
- (A) Proper motion
  - (B) Radial velocity
  - (C) Space velocity
  - (D) Transverse velocity
29. The famous tuning fork-shaped galaxy classification scheme widely used today was named after American astronomer \_\_\_\_\_
- (A) Edwin Hubble
  - (B) James Fisher
  - (C) Richard Tully
  - (D) Sandra Faber
30. The Milky Way that we live in is a \_\_\_\_\_
- (A) Barred spiral galaxy
  - (B) Spiral galaxy
  - (C) Elliptical galaxy
  - (D) Irregular galaxy

31. The presence of gas and dust lanes in spiral galaxies are best observed via \_\_\_\_\_.
- (A) X-ray
  - (B) Ultraviolet radiation
  - (C) Visible light
  - (D) Radio waves
32. 'Cosmology' is the study of
- (A) The mechanics and dynamics of celestial objects in the Solar System
  - (B) The physical processes and phenomena within the Milky Way
  - (C) The morphology and interaction of galaxies
  - (D) The structure and evolution of the entire universe as a whole
33. The Sloan Great Wall observed by the Sloan Digital Sky Survey (SDSS) is known as a \_\_\_\_\_, which is a form of large-scale structure (LSS) in the universe.
- (A) Bubble
  - (B) Filament
  - (C) Quasar
  - (D) Void
34. The assumption that our universe is \_\_\_\_\_ and \_\_\_\_\_ on sufficiently large scales is known as the cosmological principle.
- (A) Homogeneous, isotropic
  - (B) Homogeneous, anisotropic
  - (C) Heterogeneous, isotropic
  - (D) Heterogeneous, anisotropic

35. The equations  $x = r \cos \theta$  and  $y = r \sin \theta$  convert vectors from Cartesian  $(\hat{x}, \hat{y})$  to polar  $(\hat{r}, \hat{\theta})$  coordinates. can be related to  $x$  and  $y$  via the equation

(A)  $\theta = \cos^{-1} \left( \frac{y}{x} \right)$

(B)  $\theta = \sin^{-1} \left( \frac{y}{x} \right)$

(C)  $\theta = \tan^{-1} \left( \frac{y}{x} \right)$

(D)  $\theta = \sqrt{x^2 + y^2}$

36. Given the matrices  $A = \begin{pmatrix} 2 & 3 \\ 1 & 4 \end{pmatrix}$ ,  $B = \begin{pmatrix} 5 & 1 \\ 0 & 2 \end{pmatrix}$ , calculate  $(A + B)^2$

(A)  $\begin{pmatrix} 32 & 25 \\ 6 & 23 \end{pmatrix}$

(B)  $\begin{pmatrix} 53 & 52 \\ 13 & 40 \end{pmatrix}$

(C)  $\begin{pmatrix} 29 & 10 \\ 1 & 20 \end{pmatrix}$

(D)  $\begin{pmatrix} 49 & 16 \\ 1 & 36 \end{pmatrix}$

37. Given two vectors in Cartesian coordinates  $\vec{a} = \begin{pmatrix} 3 \\ 2 \end{pmatrix}$  and  $\vec{b} = \begin{pmatrix} -1 \\ 4 \end{pmatrix}$ , use  $a \cdot b = |a| |b| \cos \theta$  to calculate the angle between these two vectors.

(A)  $1.23^\circ$

(B)  $70.35^\circ$

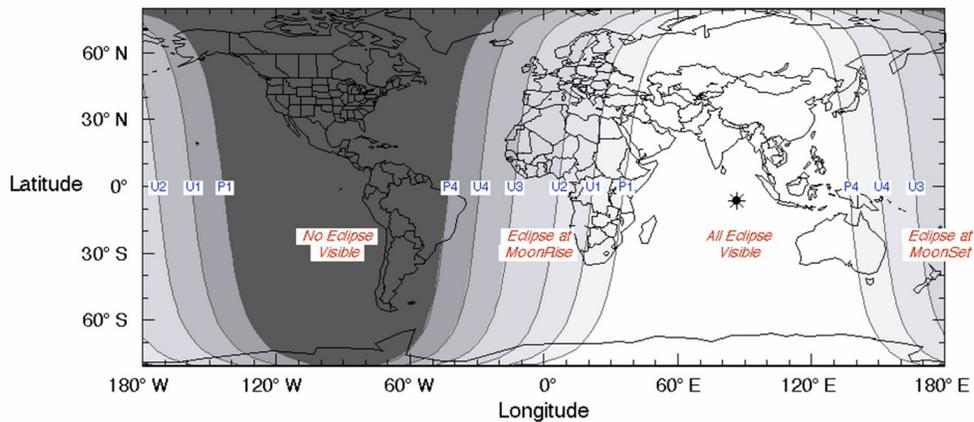
(C)  $70.53^\circ$

(D)  $78.46^\circ$

38. As of 2024, roughly how many exoplanets have been discovered?
- (A) 5 hundred
  - (B) 5 thousand
  - (C) 5 million
  - (D) 5 billion
39. A solar nebula is a cloud of gas and dust
- (A) Which acts as a progenitor of a new planetary system
  - (B) Left behind after a low-mass star turns into a white dwarf
  - (C) Dissipated after an explosion of a supernova
  - (D) Surrounding a galaxy which blocks visible light from penetrating through
40. Which of the following is NOT a method currently used to discover exoplanets?
- (A) The Doppler effect
  - (B) Orbital motion tracking
  - (C) Planetary transits
  - (D) Space probe visitation

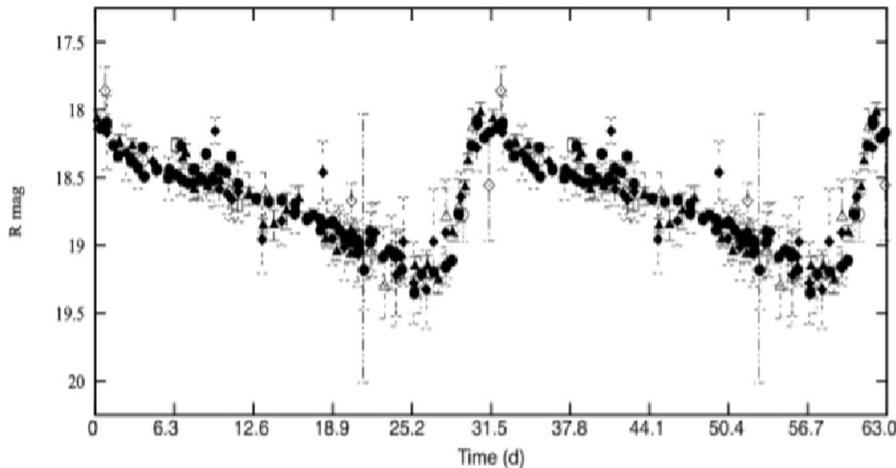
## PRACTICAL QUESTIONS

41. The picture below shows the visibility map of the Total Lunar Eclipse of 7 September 2025. Which statement below is COMPLETELY CORRECT concerning the phenomena that can be observed from Penang during the whole eclipse?



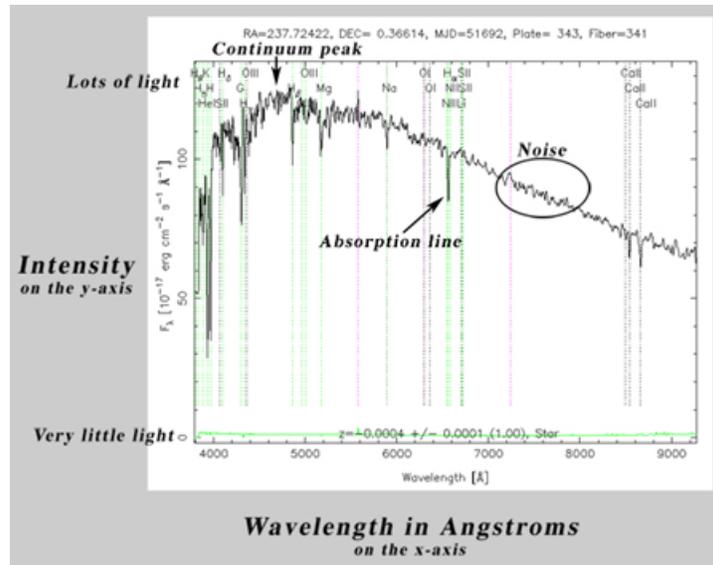
- (A) During moonrise the Full Moon is already under partial eclipse, the Moon becomes red in colour during the total phase of the lunar eclipse, the end of the lunar eclipse is still visible.
- (B) During moonrise the Full Moon is not yet under eclipse, the Moon becomes red in colour during the total phase of the lunar eclipse, the end of the lunar eclipse is not visible
- (C) During moonrise the Full Moon is not yet under eclipse, the Moon becomes red in colour during the total phase of the lunar eclipse, the end of the lunar eclipse is visible
- (D) During moonrise the Full Moon is under total lunar eclipse and the Moon becomes red in colour, the end of the lunar eclipse is visible

42. A primary school student in Penang has made his own sundial. Which of the answers below is the COMPLETELY CORRECT method to use the sundial to read the time correctly.
- (A) Place the sundial on a flat horizontal surface, make sure the sundial will be in direct sunlight all day, point the gnomon towards the north
  - (B) Place the sundial on a flat horizontal surface, make sure the sundial will be in direct sunlight all day, point the gnomon towards the south
  - (C) Place the sundial on a vertical surface, make sure the sundial will be in direct sunlight all day, point the gnomon towards the south
  - (D) Place the sundial on a vertical surface, make sure the sundial will be in direct sunlight all day, point the gnomon towards the north
43. The figure below shows the light curve of a Cepheid variable in Andromeda Galaxy (Messier 31). A lot of information can be inferred from this light curve. Which of the answers below is COMPLETELY CORRECT concerning the Cepheid variable in Andromeda Galaxy?



- (A) Can obtain the period of the Cepheid variable and using the period-distance relation we can obtain the distance to Andromeda Galaxy
  - (B) Can obtain the period of the Cepheid variable and using the Tully-Fisher relation we can obtain the rotational velocity of Andromeda Galaxy
  - (C) Can obtain the period of the Cepheid variable and obtain the mass of Andromeda Galaxy
  - (D) Can obtain the period of the Cepheid variable and using the period-luminosity relation we can obtain the distance to Andromeda Galaxy.
-

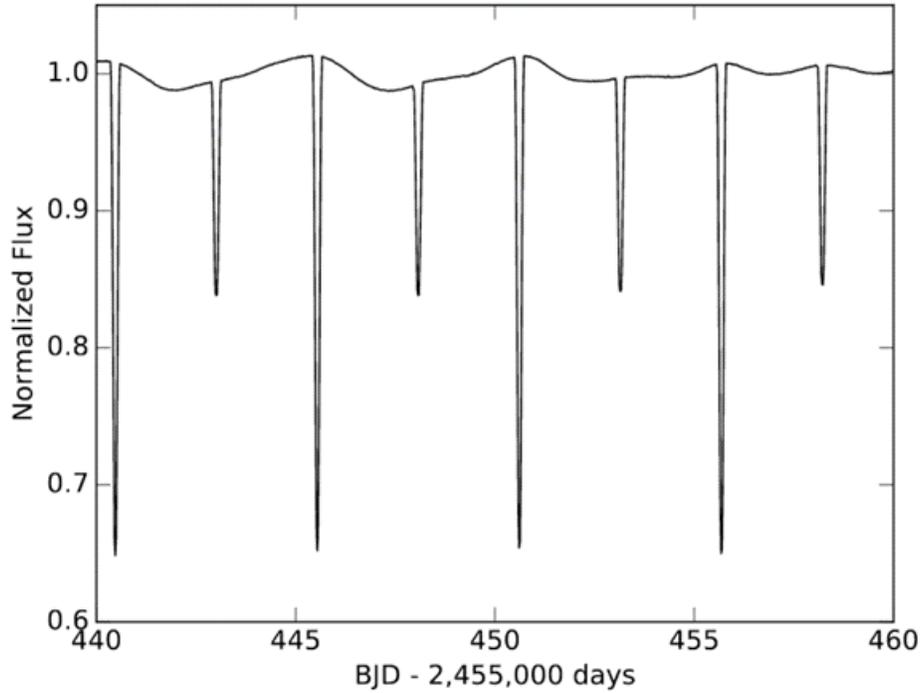
44. The figure below is the graph of the amount of light that a star gives off at different wavelengths (spectrum). Which of the answers below is COMPLETELY CORRECT concerning the information about the star that can be obtained from this spectrum?



- (A) The continuum peak tells us about the spectral class of the star, the absorption lines tell us about the abundances of the elements in the star's atmosphere and the noise is much smaller than the absorption lines.
- (B) The continuum peak tells us about the age of the star, the absorption lines tells us about the abundances of the elements in the star's atmosphere and the noise is much smaller than the absorption lines.
- (C) The continuum peak tells us about the spectral class of the star, the emission lines tell us about the abundances of the elements in the star's atmosphere and the noise is much smaller than the emission lines.
- (D) The continuum peak tells us about the mass of the star, the absorption lines tell us about the abundances of the elements in the star's atmosphere and the noise is much smaller than the absorption lines.
45. Assume that an average globular cluster is 25 pc in diameter. If you observe a galaxy that contains globular clusters that are 2 arc seconds in diameter. How far away is the galaxy?

- (A) 0.1 Mpc  
 (B) 2.0 Mpc  
 (C) 2.6 Mpc  
 (D) 3.6 Mpc

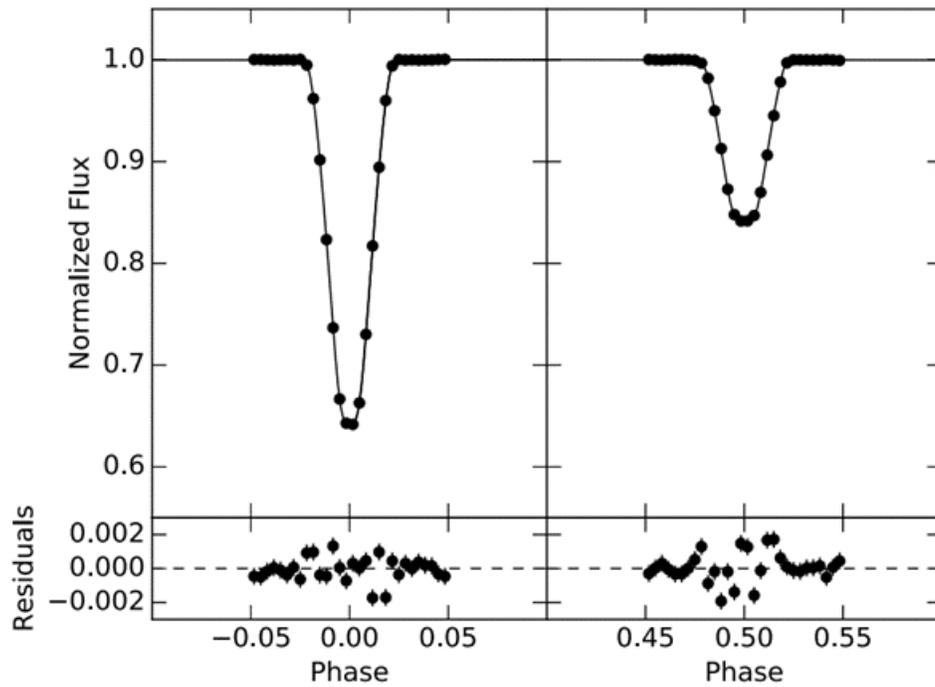
46. Below is a normalized light curve of an eclipsing binary KIC 8736245 produced by the Kepler Space Telescope



Calculate the period of its orbit in days

- (A) 5 days
- (B) 2.5 days
- (C) 10 days
- (D) 5,000 days

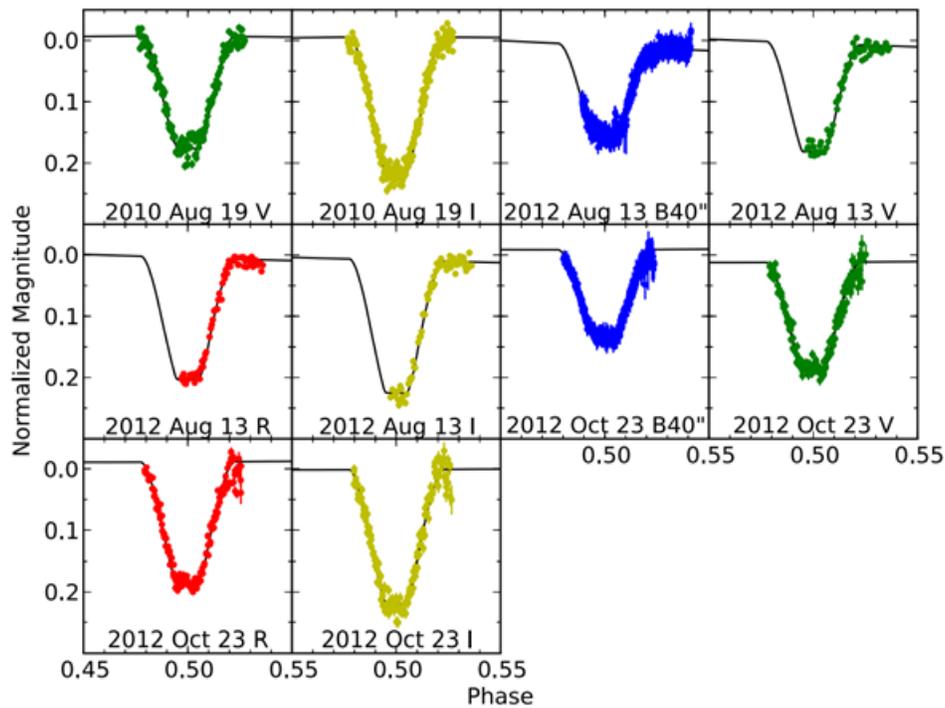
47. The graph below shows the primary and secondary eclipse of the same system; eclipsing binary KIC 8736245 observed by the same team of researchers.



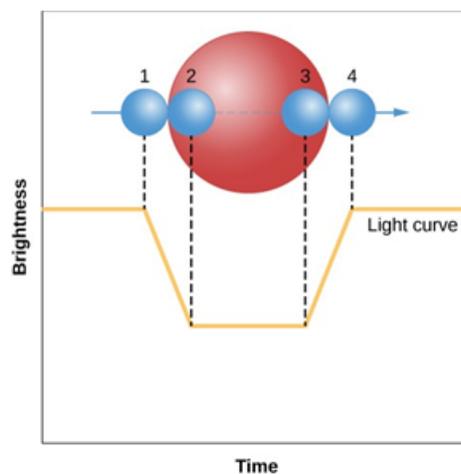
What is the duration of the eclipse? Measure the two widths and average them. Express the result in terms of Seconds

- (A) 0.04
- (B) 0.40
- (C)  $1.73 \times 10^4$
- (D)  $4.32 \times 10^5$

48. From the observation of the eclipsing binary KIC 8736245 in the previous question, the researchers made a model based on the data observed of the secondary eclipse.

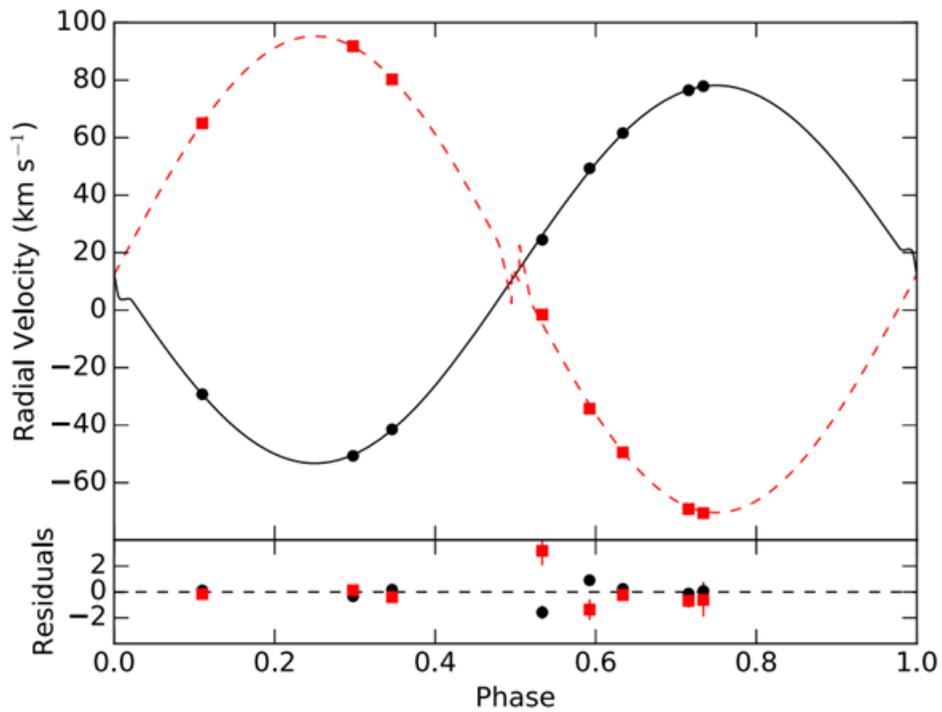


Using the lightcurve of “2012 Aug 13 I”, measure the timing  $t_4 - t_1$  and  $t_3 - t_2$ , in seconds if the configuration is as follows



	$t_4 - t_1$	$t_3 - t_2$
(A)	0.040	0.014
(B)	$1.73 \times 10^4$	$6.05 \times 10^3$
(C)	0.0140	0.040
(D)	$6.05 \times 10^3$	$1.73 \times 10^4$

49. The researcher also observed the radial velocities of the eclipsing binary star system KIC 8736245. Below is the observed result, with the best fit



Calculate the maximum speed away from the systematic velocity for each star, or the amplitude of each star's motion. Let's take the red as star a and the black as star b

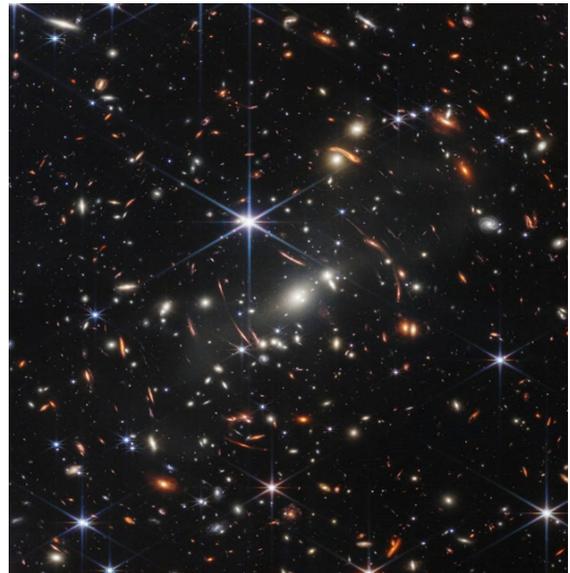
	$V_a(\text{kms}^{-1})$	$V_b(\text{kms}^{-1})$
(A)	67	82
(B)	98	80
(C)	80	98
(D)	82	67

50. Calculate the ratio of the mass between the two component star in the binary star system KIC 8736245
- (A) 0.817
  - (B) 1.225
  - (C) 1.000
  - (D) 0.4
51. Calculate the mass of each individual star in the binary star system KIC 8736245.  
HINT: Kepler's third law might be involved
- (A)  $0.99M_{\odot}$  and  $0.78M_{\odot}$
  - (B)  $0.50M_{\odot}$  and  $0.50M_{\odot}$
  - (C)  $0.43M_{\odot}$  and  $0.50M_{\odot}$
  - (D)  $0.99M_{\odot}$  and  $0.50M_{\odot}$

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



Object 1



Object 2



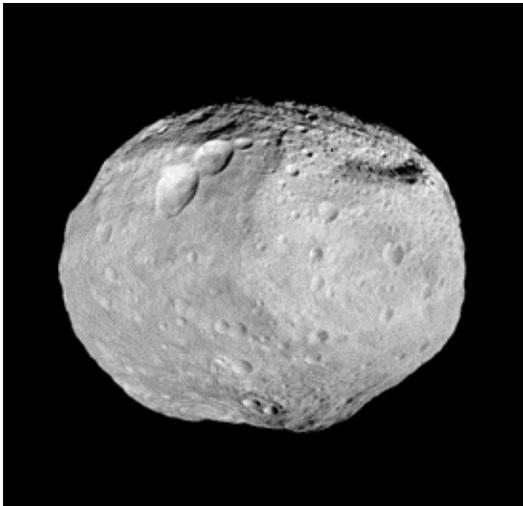
Object 3



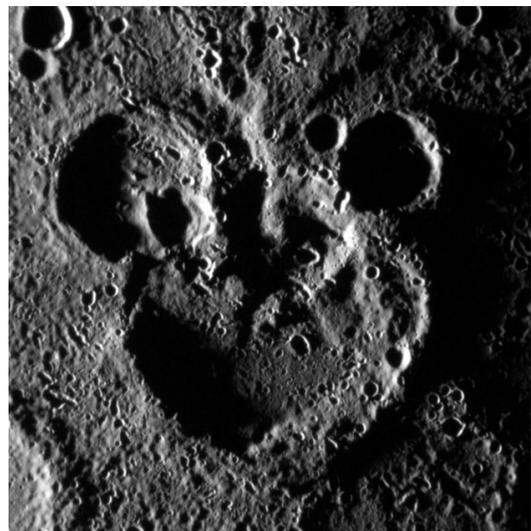
Object 4

	Object 1	Object 2	Object 3	Object 4
(A)	Orion	Cygnus	Scorpius	Gemini
(B)	Gemini	Pegasus	Cygnus	Orion
(C)	Carina	Volans	Cygnus	Orion
(D)	Canis Major	Aquarius	Libra	Bootes

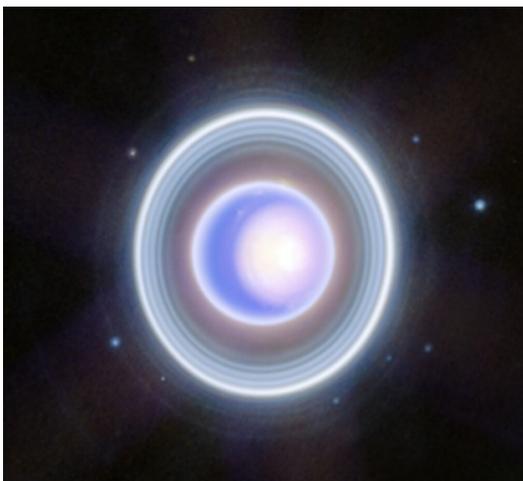
53. The four pictures below show four astronomical objects in the Solar System. Which of the answers below is the COMPLETELY CORRECT MATCH of the four astronomical objects?



Object 1



Object 2



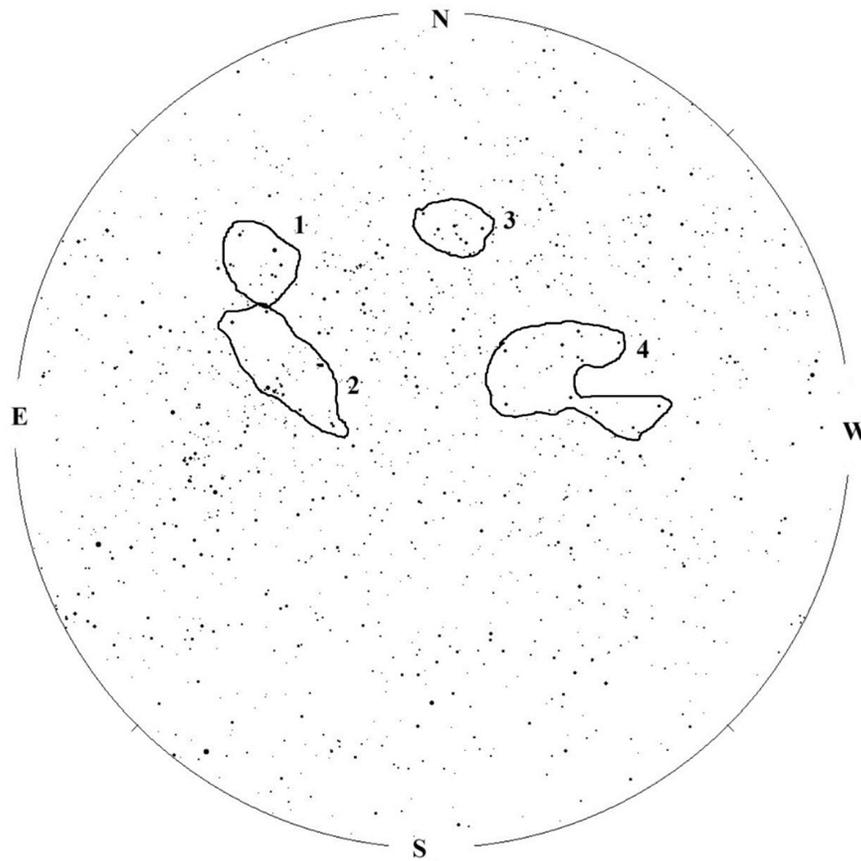
Object 3



Object 4

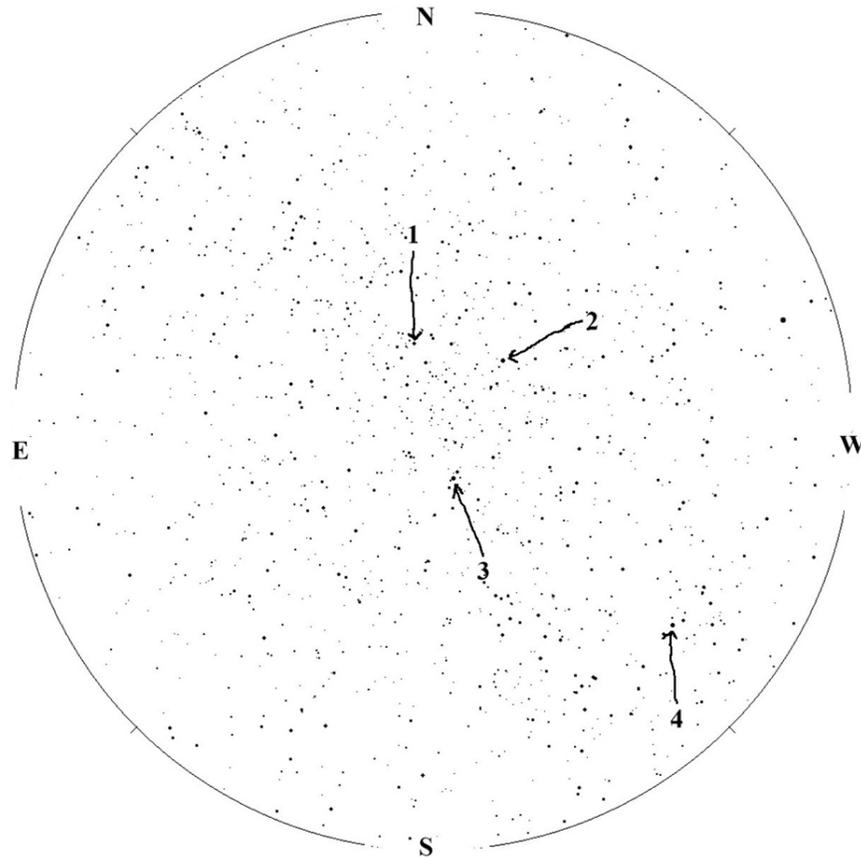
	Object 1	Object 2	Object 3	Object 4
(A)	Asteroid 2 Pallas	Crater on Venus	Saturn	Pluto
(B)	Asteroid 4 Vesta	Crater on Mercury	Uranus	Pluto
(C)	Asteroid 3 Juno	Crater on Moon	Neptune	Ceres
(D)	Asteroid 7 Iris	Crater on Mars	Saturn	Ceres

54. In the star chart below are drawn the boundaries of four constellations. Which of the answers below shows the COMPLETELY CORRECT MATCH of the constellations with their names?



	1	2	3	4
(A)	Gemini	Orion	Cassiopeia	Aquarius
(B)	Aquila	Capricornus	Bootes	Virgo
(C)	Cygnus	Aquila	Bootes	Libra
(D)	Auriga	Taurus	Cassiopeia	Pegasus

55. In the star chart below are shown the four pointers pointing at four stars. Which of the answers below shows the COMPLETELY CORRECT MATCH of the pointers pointing to the stars?



	1	2	3	4
(A)	Deneb	Vega	Altair	Antares
(B)	Formalhaut	Markab	Arcturus	Spica
(C)	Vega	Sirius	Betelgeuse	Pollux
(D)	Deneb	Markab	Altair	Spica

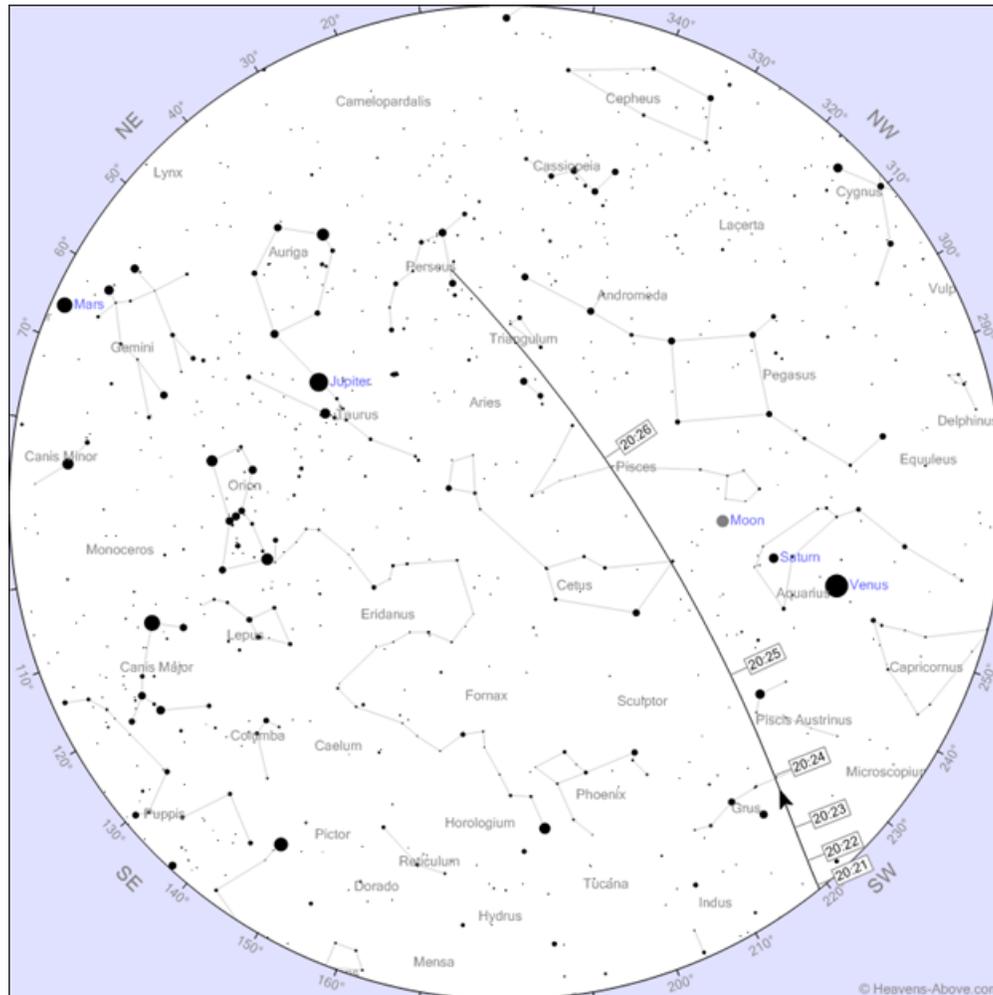
**MAPS AND IMAGES QUESTIONS**

56. The picture below is an astrophotograph of the Milky Way Galaxy captured by an amateur astrophotographer. Which of the descriptions below is MOST CORRECT concerning the astrophotography technique used to capture this image?



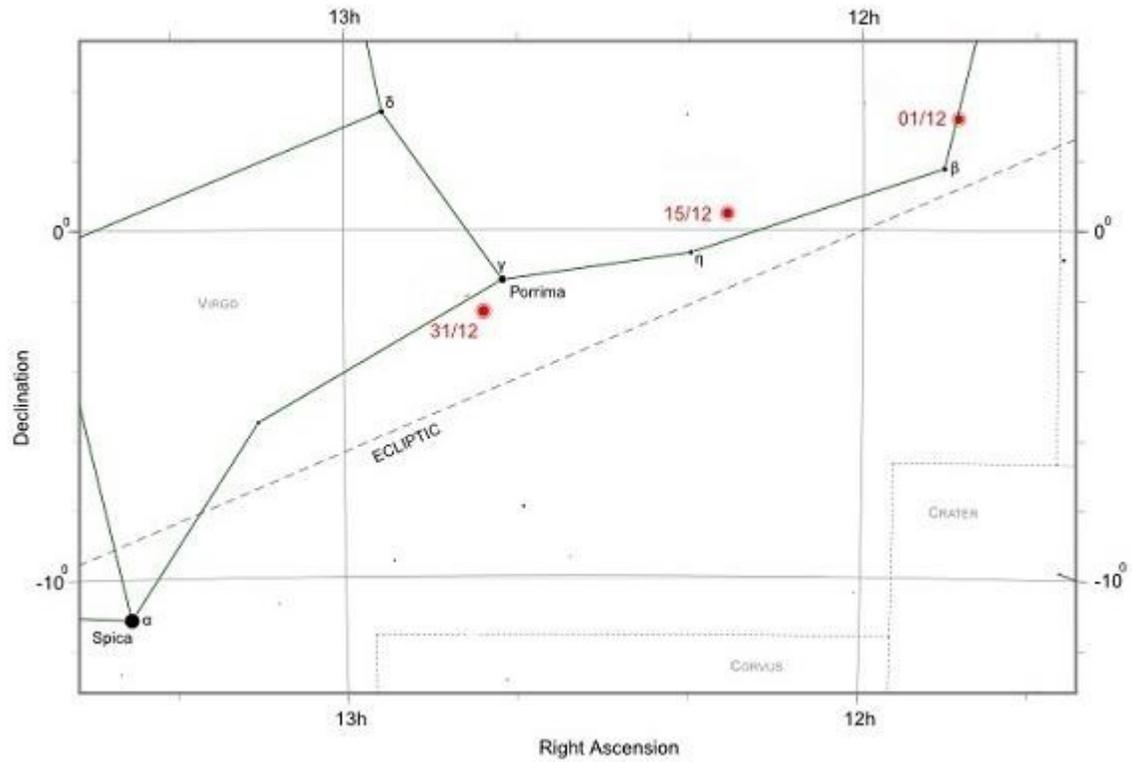
- (A) Use a DSLR camera with a 15 mm lens, use the camera in manual mode, take a 3-minute exposure with ISO set to 100
- (B) Use a DSLR camera with a 15 mm lens, use the camera in manual mode, take a 30-second exposure with ISO set to 1600
- (C) Use a DSLR camera on a German-Equatorial tracking mount, use the camera in Full Auto mode, take a 1-second exposure with ISO set to 1600
- (D) Use a DSLR camera attached to a 6-inch aperture APO refracting telescope on a German-Equatorial tracking mount, use the camera in manual mode, take a 30-second exposure with ISO set to 1600

57. In the star chart below, an object that appears as a point of light that was not blinking, moved across the sky, as marked by the arrow, with the time included to mark the exact location. Based on its motion and appearance, determine the object



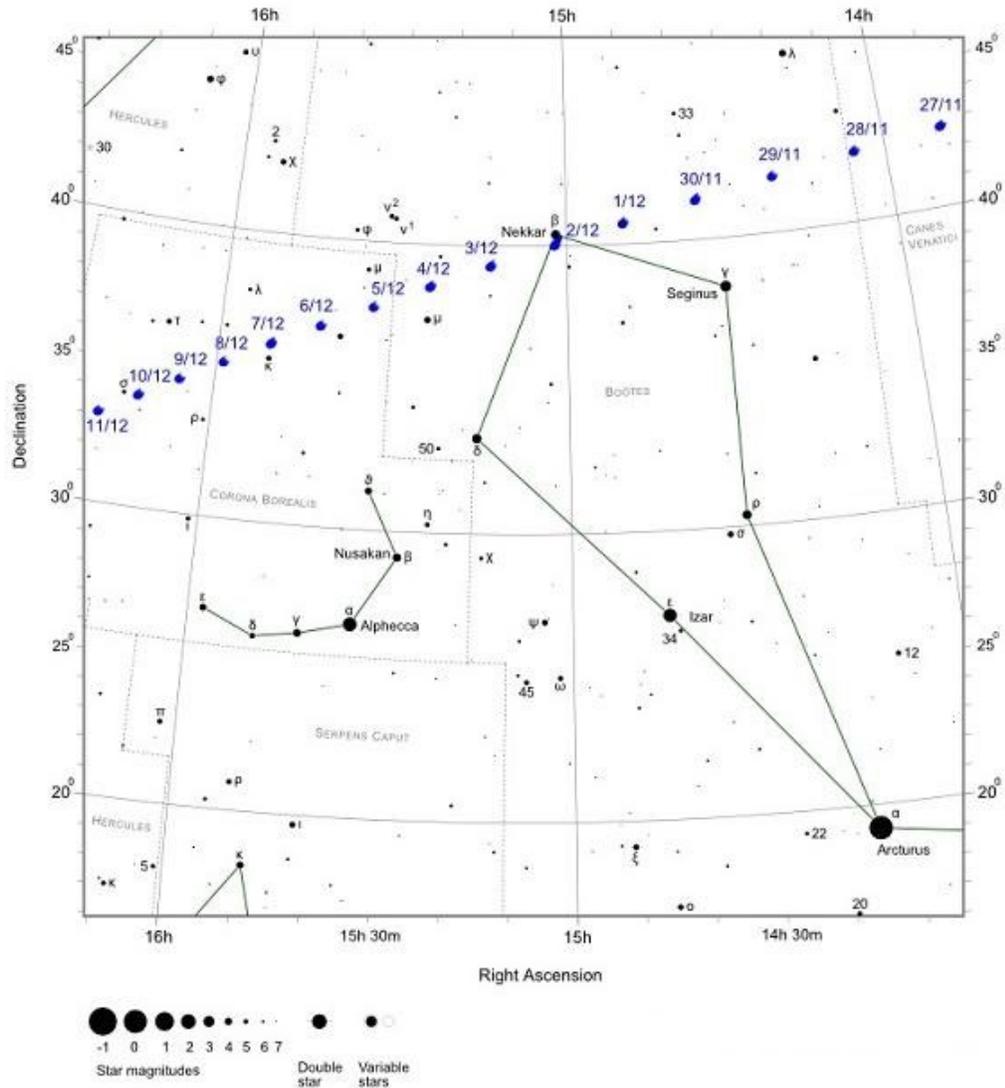
- (A) The International Space Station
- (B) A Comet
- (C) A meteor
- (D) A plane

58. In the star chart below, a point-light source is moving across the sky, as marked by the arrow, with the date included to mark the exact location. Based on its motion, determine the object



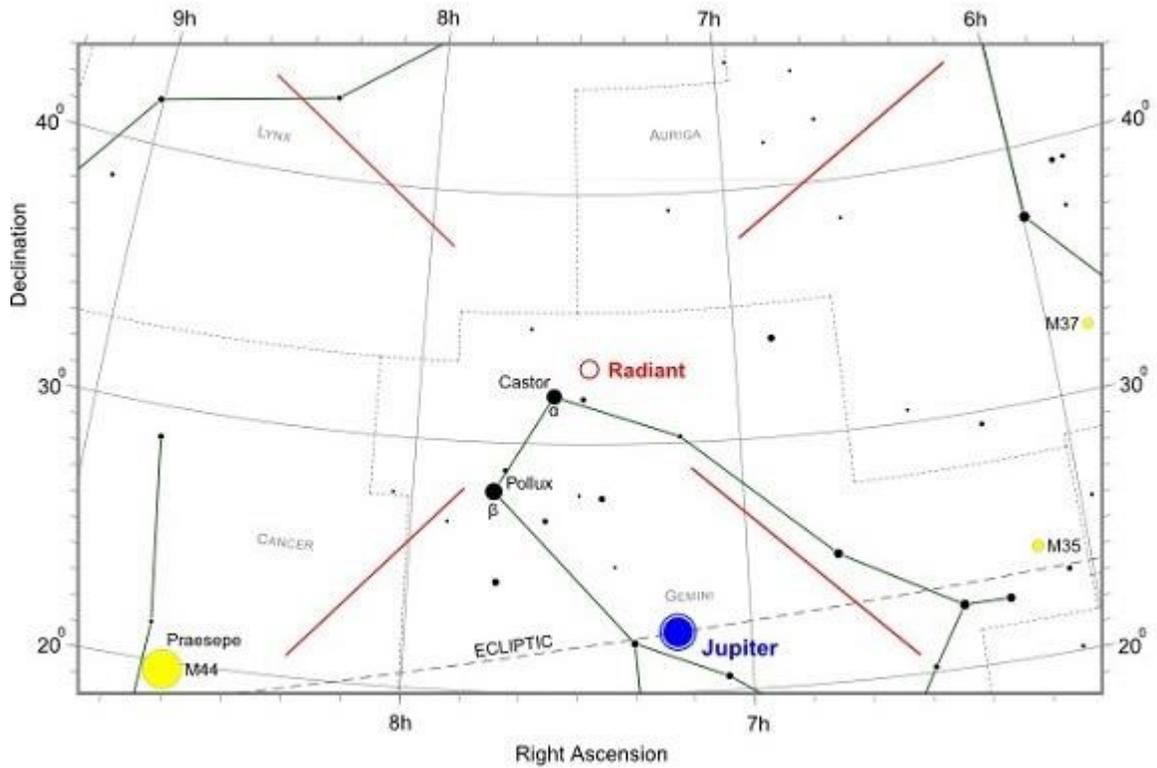
- (A) Jupiter
- (B) Moon
- (C) Mars
- (D) Uranus

59. In the star chart below, a diffused light source with a tail is moving across the sky, as marked by the blue points, with the date included to mark the exact location. Based on its appearance and motion, determine the object



- (A) Meteor
- (B) SpaceX
- (C) Asteroid
- (D) Comet

60. In the star chart below, a few diffused light sources move across the sky in a split seconds and leave a trail of light in the process. The motion is marked by the red lines, radiating from the radiant point. Based on its appearance and motion, determine the object



- (A) Meteors
- (B) Comets
- (C) Supernova
- (D) Asteroids

END OF QUESTION PAPER