

Section A: MCQ

Q1. Which of the following is the largest?

- a. The radius of the Crab pulsar
- b. Schwarzschild radius of Sirius
- c. The geometric mean of Planck length and the observable universe
- d. The diameter of the Large Hadron Collider

Q2. Mars has an albedo of 0.16. Its apparent magnitude is -2.91. Suppose now it has an albedo of 1 – what is its new apparent magnitude?

- a. -0.92
- b. -9.16
- c. -3.34
- d. -4.90

Q3. Estimate the (civil) time in which an observer in Beijing (39.9° N, 116.4° E, GMT +8) would observe the sun rising from the horizon on December 21.

(Ignore the effects of atmospheric refraction and the equation of time.)

- a. 7:12 am
- b. 7:25 am
- c. 7:24 am
- d. 7:39 am

Q4. What would the length of a sidereal day be if the Earth started rotating eastwards instead of westwards, at the same speed?

- a. 23 h 52 m 8 s
- b. 23 h 56 m 4 s
- c. 24 h 3 m 56 s
- d. 24 h 7 m 52 s

Q5. An observer in Tokyo (35.6 degrees N) spots a satellite transiting the local meridian with a zenith angle of 52 degrees. The satellite orbits along the celestial equator. Calculate its distance from the centre of the Earth, in units of Earth radii.

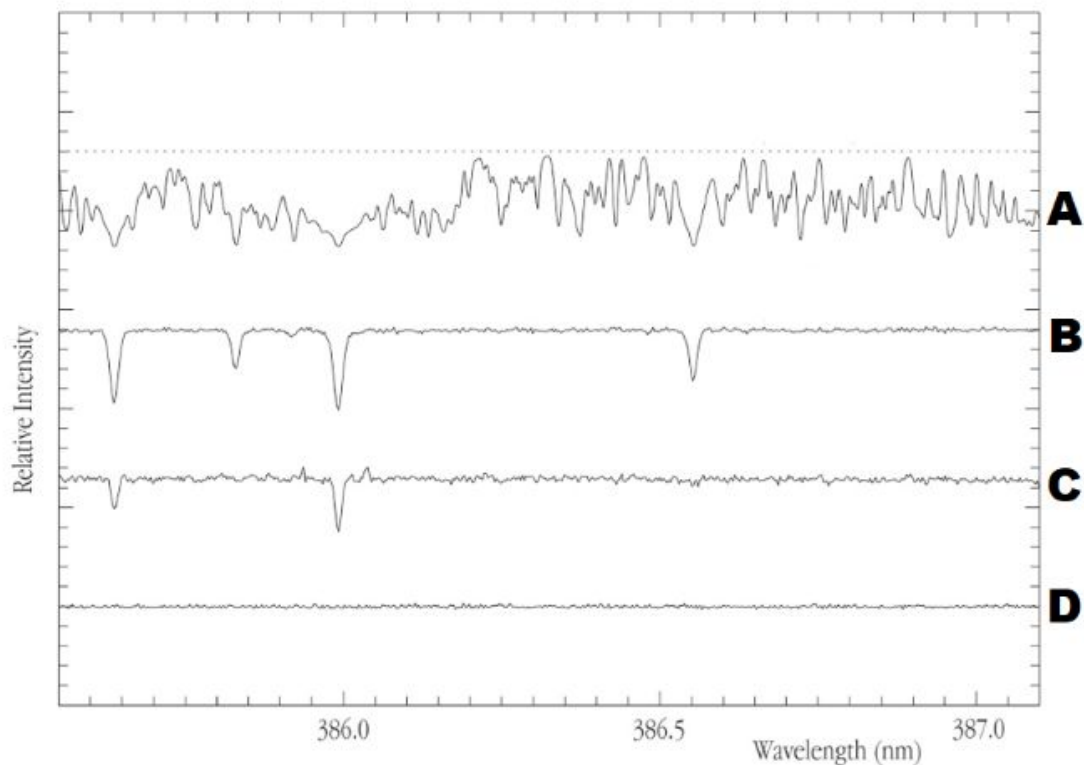
- a. 2.79 earth radii
- b. 3.16 earth radii
- c. 8.34 earth radii
- d. 14.70 earth radii

Q6. Consider a globular cluster of diameter 20 parsecs. It has an escape velocity of 6 km / s at the edge of the cluster. If each star has a mass of about twice that of our Sun, how many stars are there in the globular cluster? (1 pc = 3.26 ly, Mass of sun is about 2×10^{30} kg.)

- a. 20 000 stars
- b. 40 000 stars
- c. 80 000 stars
- d. 160 000 stars

Q7. A supernova remnant in the sky has a total angular size of 5 arcminutes. We know that the remnant is 250 parsecs away from Earth. If the remnant expanded in a spherical shape with a constant expansion speed of 20 km/s, how long ago did this supernova approximately take place, as seen from the Earth?

- a. 5.5 months ago
- b. 8900 years ago
- c. 4.02×10^{20} years ago
- d. Not enough information to tell

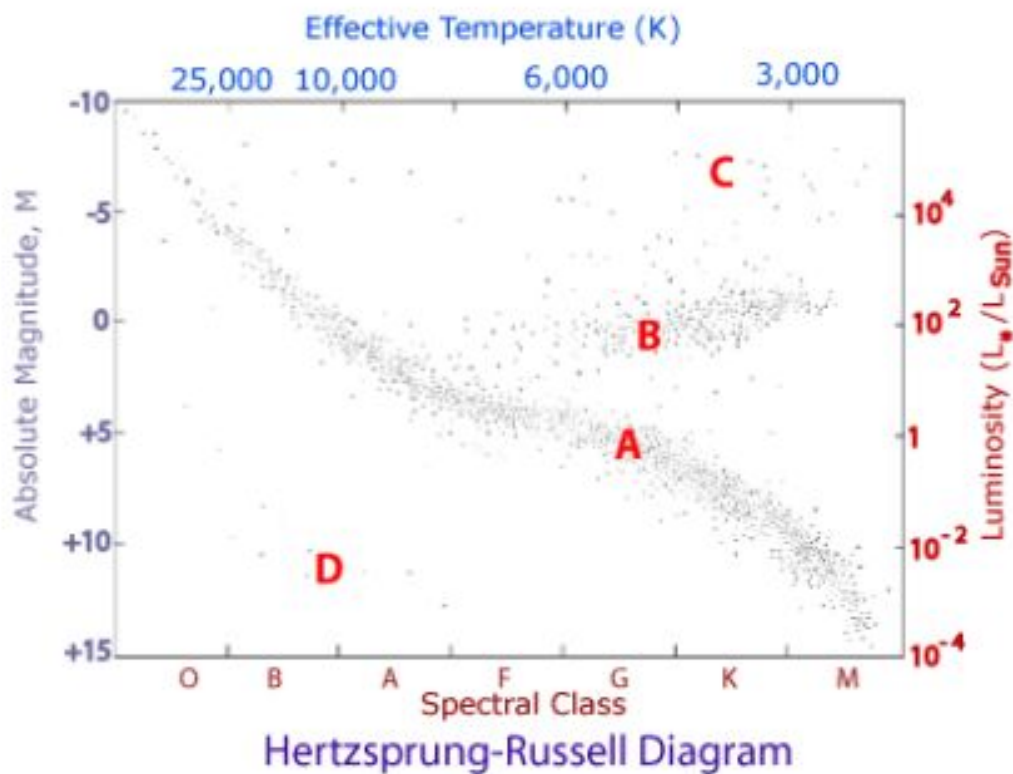


Q8. Which of these spectra best resembles (i) the sun, (ii) a Population III star?

- a. D, A
- b. A, C
- c. A, D
- d. C, A

Q9. A star has a temperature of 5800 K. A dust grain is 215 stellar radii away from the star. Assuming that the dust grain is spherical and a perfect blackbody, what is its equilibrium temperature?

- a. 13 K
- b. 27 K
- c. 280 K
- d. 396 K



Q10. Which letter corresponds to the white dwarfs?

- a. A
- b. B
- c. C
- d. D

Q11. Which group would you likely NOT find within 50 ly of our Sun?

- a. A
- b. B
- c. C
- d. D

Q12. Neutron stars have atmospheres, just like the Earth. However, the gravity of neutron stars is far larger than the Earth. Given that the Earth has an atmosphere of about 100 km thickness, guesstimate the thickness of the atmosphere of a neutron star.

- a. 200 mm
- b. 2 m
- c. 200 m
- d. 2 km

Q13. An exoplanet transits across a distant star, causing its apparent brightness to dip by 1% over a duration of two hours. What conclusions can we draw about the planet?

- a. Its radius is 1% that of the star.
- b. Its orbital period is 200 hours
- c. Its diameter is 1/10 of the star.
- d. The planet is a gas giant.

Q14. The first elements were formed shortly after the Big Bang. During this phase of the universe, there was 1 neutron for every 7 protons. Some neutrons fuse with protons to form helium, resulting in an observed mass fraction of 25% helium and 75% hydrogen. Suppose in an alternate universe there were 1 neutron for every 5 protons. What would the mass fraction of helium in this alternate universe?

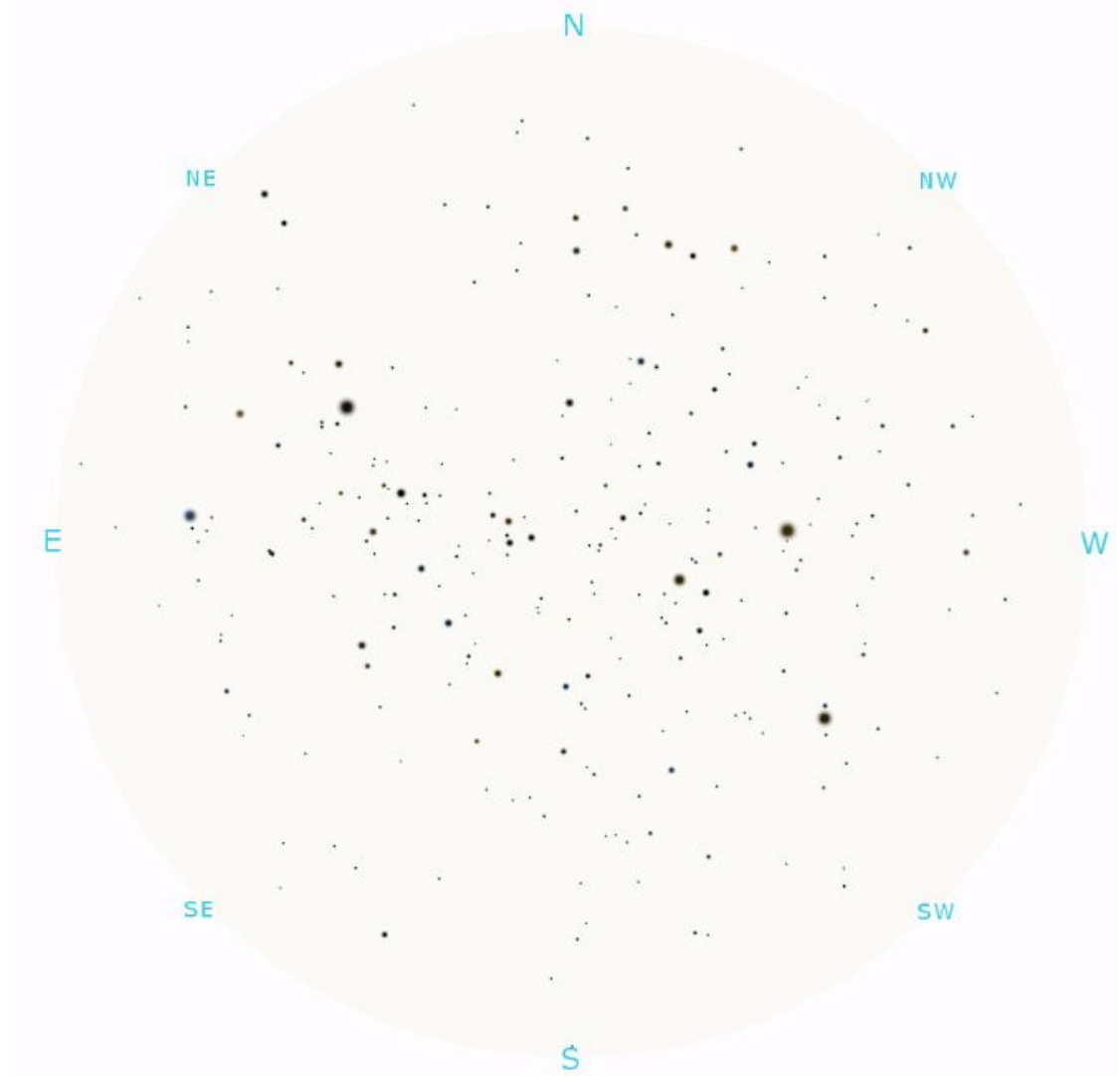
- a. 25%
- b. 33%
- c. 40%
- d. 50%

Q15. A quasar has a redshift of $z = 1.4$. Estimate its distance, to one significant figure. (Take the Hubble constant as $70 \text{ km s}^{-1} \text{ Mpc}^{-1}$)

- a. 800 Mpc
- b. 3000 Mpc
- c. 6000 Mpc
- d. 8000 Mpc

Q16. What is the smallest feature resolvable by a naked eye of diameter 5 mm? The distance to the moon from the Earth is about $3.78 \times 10^8 \text{ m}$.

- a. 26 km
- b. 46 km
- c. 66 km
- d. 86 km



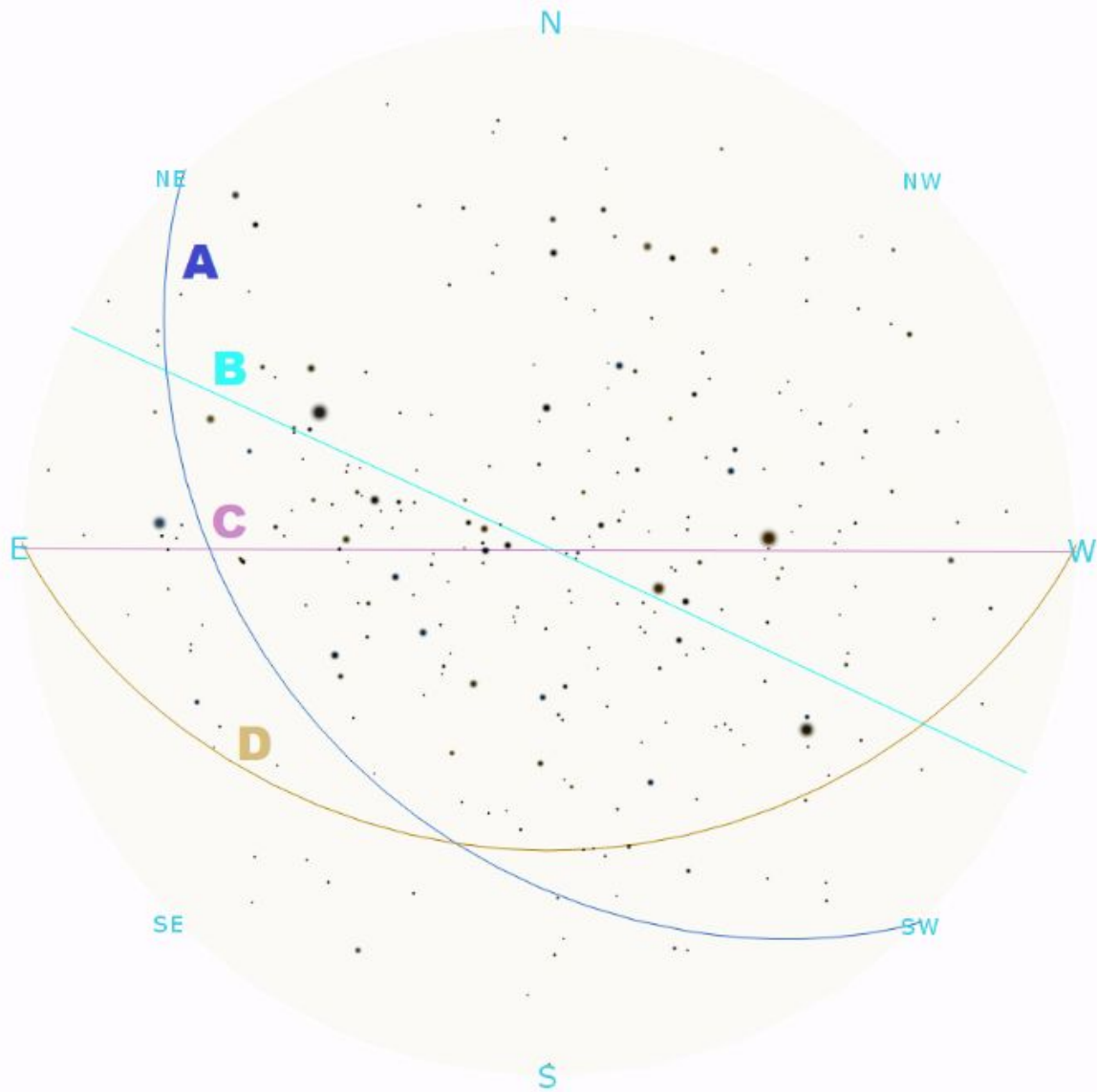
Here is a negative image of a simulated sky seen at midnight.

Q17. Which month's sky is captured in this image?

- a. March
- b. June
- c. September
- d. December

Q18. Which location was this sky captured from?

- a. Singapore (1.3521° N, 103.8198° E)
- b. Honolulu, Hawaii (21.3069° N, 157.8583° W)
- c. Tehran, Iran (35.6892° N, 51.3890° E)
- d. Bishkek, Kyrgyzstan (42.8746° N, 74.5698° E)
- e. Tallinn, Estonia (59.4370° N, 24.7536° E)



Q19 Which line shows the ecliptic?

- a. A
- b. B
- c. C
- d. D

Q20 Which line shows the celestial equator?

- a. A
- b. B
- c. C
- d. D