7923

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Unique Paper Code	:	2223010013
Name of the Paper	:	Astronomy and Astrophysics (DSE Paper)
Name of the Course	:	B.Sc. Hons.–(Physics)_NEP: UGCF-2022
Semester	:	V
Duration	:	3 hours
Maximum Marks	:	90

Instructions for Candidates

1. Write your Roll on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all.
3. Question No. 1 is compulsory.
4. Use of non-programmable scientific calculators is allowed.

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1. Attempt any six of the following:

(a) Show the location of the Sun on Winter Solstice (Dec 21-22) in a diagram of equatorial coordinate system. What are Sun's declination and right ascension on this day? –

(b) Draw the night tracks of stars for an observer at Equator. Show the track of the Sun on Summer solstice for this observer, and locate the position of the sunrise and sunset on her horizon.

(c) If the minimum measurable parallax angle for a certain instrument is 10 arcseconds, what is the maximum distance at which the instrument can measure an object's parallax if (a) the baseline is equal to the Earth's diameter about 12,500 km and (b) the baseline is diameter of the Earth's orbit.

(d) The brightest stars are around 10^5 times brighter than the Sun. If the apparent magnitude of these bright stars in a galaxy is 22.5, how far away is the galaxy?

(e) The apparent diameter of the Sun is 32' (arc-minutes) and the flux of solar radiation received on the Earth is 1370 W/m^2. What is the flux density at the surface of the Sun?

(f) Determine the value of α in the density profile ($\rho(r) \propto r^{\alpha}$) for a spherically symmetric mass distribution in a flat rotation curve.

(g) Given that a globular cluster is 14 Gyr old, what is the upper limit on the Hubble constant in units of $kms^{-1}Mpc^{-1}$, assuming that the rate of expansion of the Universe has remained constant?

$(3 \times 6 = 18)$

2. a) Define the elements and coordinate angles of the horizon coordinate system. Draw a diagram showing the horizon coordinate system of an observer located at Delhi (30^0 N).

(b) Show the hour angle of a star X on the local equatorial coordinate system of an observer at latitude ϕ. The local sidereal time (LST) is defined as the hour angle of the vernal equinox. Prove that for a star X, HAX = LST – RAX, where HAX is the hour angle of X and RAX is its right ascension.

(c) What are circumpolar stars? A star has declination $\delta = 40^0$. If it is viewed from a point on the Arctic Circle (66.7^0N) what are its maximum and minimum zenith distances?

(6,8,4)

3. (a) The shadow of a 2 m tall pole at a place is 1 m on the noon of winter solstice, when the Sun is at its highest point in the sky. What is the latitude of the place?

(b) Discuss the classification of stars based on their temperature and luminosity. Draw the main sequence, red giant and super giant branches on an HR-diagram. Why are He lines prominent in O type stars and absent in K type stars?

(c) Draw the cosmic distance ladder. What are type Ia supernovae and how are they used to estimate astronomical distances?

(6, 6, 6)

4. (a) The Sirius is a visual binary star system with components Sirius A and Sirius B. It has annual parallax of 0.38" (arcsec). The largest parallax of the separation between the two components is 12", and the minimum is 3". What is the semi-major axis and eccentricity of the relative orbit? The orbital period is found to be 50 years. What is the total mass of the system? If the semi-major axis of the obit of Sirius B is double of that of Sirius B, find values of their individual masses.

(b) Discuss the different observational properties of visual, spectroscopic and eclipsing binary star systems. How do these properties help determine stellar masses and radii? Why is the number of visual and eclipsing binaries observed very small compared to spectroscopic binaries?

(b) Suppose the sun swells to 200 times its present radius while its surface temperature becomes half. Calculate its luminosity in terms of its present luminosity.

(8, 6, 4)

5. (a) Show that the magnetic flux is frozen with the hot plasma of large bodies like stars. How does this explain the very high temperature of the Sun's Corona relative to lower layers of its atmosphere.

(b) Discuss the internal structure of the Sun, with respect to energy generation and transmission. What is the evidence that convection is the chief form of energy transport below its surface?

(c) Give a description of the following with respect to their main properties like size, density, temperature, and the properties of radiation emitted.

(i) photosphere (ii) sun spots (iii) chromosphere , and (iv) Corona.

(10,4,4)

6. (a) Explain the meaning of scale factor $R(t)$ as defined in cosmology. Starting from Newtonian cosmology, derive the Friedmann equation in terms of scale factor. Show that for a flat universe, the scale factor evolves with time (t) as $R(t) \propto t^{2/3}$.

(b) Explain any one indirect evidence which supports the existence of dark matter in our universe.

(c) A globular cluster contains 100,000 stars of $1M_{\odot}$ each within a radius of 20 pc. Use virial theorem to estimate the average velocity of stars assuming that the average distance between them equals the radius of the cluster. (10, 4, 4)

Useful Constants

$G = 6.67 \times 10^{-11}\ m^3kg^{-1}s^{-2}$

$k_B = 1.38 \times 10^{-23} JK^{-1}$

$\sigma = 5.67 \times 10^{-8}\ Wm^{-2}K^{-4}$

$M_{\odot} = 1.99 \times 10^{30}\ kg$

$R_{\odot} = 6.96 \times 10^{8}\ m$

$AU = 1.50 \times 10^{11}\ m$