Constants

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

Boltzmann Constant $k_B = 1.38 \times 10^{-23} JK^{-1}$ Stefans Constant $\sigma = 5.67 \times 10^{-8} Wkm^{-2} K^{-4}$

Parsec $1\,pc = 3.1 \times 10^{16}\,m$ Astronomical Unit $1\,AU = 1.50 \times 10^{11}\,m$

Mass of Earth $M_E = 5.97 \times 10^{24}\,Kg$ Radius of Earth $R_E = 6.36 \times 10^{6}\,m$

Mass of Sun $M_\odot = 1.99 \times 10^{30}\,Kg$ Radius of Sun $R_\odot = 6.96 \times 10^{8}\,m$

Apparent Magnitude of the Sun $m_\odot = -26.72$ Solar constant $S = 1370\,Wm^{-2}$

Density of the solar photosphere $\rho_{photosphere} = 4.9 \times 10^{-6}\,kgm^{-3}$

Mass of He^3 nucleus $M_{He^3} = 2808.30\,MeV$ Mass of He^4 nucleus $M_{He^4} = 3727.40\,MeV$

Mass of He nucleus $M_H = 938.27\,MeV$ Naked Eye limit of Apparent Magnitude $m_e = 6$

Oort constants $A = 15\,kms^{-1}kpc^{-1}$ & $B = -10\,kms^{-1}kpc^{-1}$

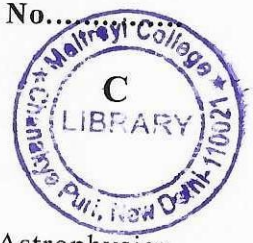
Velocity and distance of Sun about Galactic Center $v_\odot = 218 kms^{-1}$ & $r_\odot = 8\,kpc$

Mass of electron $m_e = 9.1 \times 10^{-31}\,kg$ & Charge of electron $e = 1.6 \times 10^{-19}\,C$

6 DEC

[This question paper contains 8 printed pages.]

06 DEC 2022 **Your Roll No.....**



Sr. No. of Question Paper : 1144

Unique Paper Code : 32227506

Name of the Paper : Astronomy & Astrophysics

Name of the Course : **B.Sc. (Hons) Physics – DSE**

Semester : V

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question No. **1** which is compulsory.
3. Attempt any **four** questions from the remaining.

1. Attempt any **four** of the following : (5×3=15)

(a) The lunar parallax determination was done by Hipparchus (200-BC). The measurement was done during a total solar eclipse at Syene and a partial eclipse at Alexandria where about 1/5~th of the

30~arcmin Sun's disk was visible. If the latitudes of Syene and Alexandria are 41° and 31° respectively, find the Earth- Moon distance in terms of radius of Earth.

(b) Make a rough estimate of Earth's mean temperature T by assuming that it is a perfect blackbody and spherically symmetric. Assume that it absorbs the entire solar radiation incident upon it and radiates as a blackbody at temperature T.

(c) What are circumpolar stars? What would be the declination of circumpolar stars for an observer at latitude 30°N?

(d) The apparent magnitude of Full Moon is –12.73 and that of Jupiter is –2.60. Calculate their brightness ratio.

(e) Determine the magnitude limit in the visible range that can be detected by a 1.04 m telescope.

(f) Give two arguments in support of the expanding universe as compared to the steady state universe.

The angle $\psi(\psi')$ are measured counterclockwise from the positive $x(x')$ axis along the $xy(x'y')$ plane. The angle $\theta(\theta')$ is the angular distance from the xy $(x'y')$ plane. Derive triangulation formulas for the spherical triangle ABC

$$\sin B \sin a = \sin A \sin b$$

$$\cos B \sin a = \cos A \sin b \cos c + \cos b \sin c$$

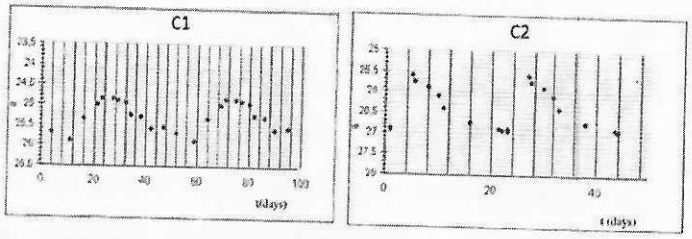
$$\cos a = -\cos A \sin b \sin c + \cos b \cos c$$

by expressing the spherical coordinates ψ, θ, ψ' and θ' in terms of the appropriate sides a,b,c and angles A,B,C of the triangle. From this deduce the sine formula. (9)

(b) The Sun's "surface" is a thin layer of the solar atmosphere called the photosphere. The characteristic temperature of the photosphere is Te = 5777~K, and it has about 500000 hydrogen atoms for each calcium atom with an electron pressure of about 1. 5 Nm^{-2}. Estimate (i) ratio of ionized to neutral hydrogen and (ii) ratio of hydrogen atoms are in the first excited state to neutral hydrogen. Find the relative number of hydrogen atoms capable of producing Balmer absorption lines. The energy needed to convert it from H I to H II, is χ_I =13.6eV. (6)

P.T.O.

Two panels show the light curves of two Cepheids.



Estimate the distances to each of these two Cepheids. Roughly estimate the uncertainty in the distance determination. Comparing the difference between the distances of the two stars with the typical size of a galaxy, would it be likely for these two stars to be in the same galaxy? (6)

7. (a) The coordinates transformation of a point P between two rectangular coordinate frames O_{xyz} and $O'_{x'y'z'}$ such that the O′ frame is obtained from the O frame by rotating it around the x axis by an angle χ is given by

$$\cos\psi' \cos\theta' = \cos\psi \cos\theta$$

$$\sin\psi' \cos\theta' = \sin\psi \cos\theta \cos\chi + \sin\theta \sin\chi$$

$$\sin\theta' = -\sin\psi \cos\theta \sin\chi + \sin\theta \cos\chi$$

(g) At what wavelength does a star with the surface temperature of 4000° K emit most intensely?

2. (a) Define the essential elements of the Local Equatorial Coordinate System and show them on an appropriate diagram. Draw the diurnal motion of a star in this coordinate system. Also draw the diurnal motion of Sun on Solstices at latitude 23°. (9)

(b) The image of an astronomical object forms at the focus of a telescope. For astronomy, one is interested in its 'angular size' (measured in arcseconds) but to photograph it you are interested in how big it will be compared to the size of your film or digital sensor array (measured in mm). An astronomer wants to design a camera so that each pixel views an angle of only o.5 arcsec. If the width of each pixel is 8~micron, what is the focal length needed for the telescope? If a digital camera array measures 20 mm across and consists of 2048 pixels, what will the telescope focal length have to be so that the array can be used to photograph a star cluster with a diameter of 15 arcmin? (6)

P.T.O.

3. (a) Write the Saha Ionization equation. What is its significance? Draw a schematic HR diagram. (9)

(b) Calculate the frequency shift produced by the normal Zeeman effect in the center of a sunspot that has a magnetic field strength of o.3~T. By what fraction would the wavelength of one component of the 630.25 nm Fe I spectral line change as a consequence of a magnetic field? (6)

4. (a) Explain the meaning of scale factor a(t) as defined in cosmology. Starting from Newtonian cosmology derive Friedmann equation in terms of scale factor and explain the model(s) of the universe based on derived equation. Using the Friedmann equation, show that for a flat universe having single fluid as non-relativistic matter or dust, the scale factor evolves as $a(t) \propto t^{2/3}$. (9)

(b) For an observer at latitude 42.5°N and longitude 71°W, estimate the local time of sun rise on 21 December. If the observer's civil time is –5 hrs from GMT find the time of sunrise as

per observer's standard watch. Ignore refraction of the atmosphere, the size of the solar disc. (6)

5. (a) State and derive Viriai theorem for bound and stable system of N particles under mutual gravitational attraction. How it can be used to make an order-of-magnitude estimate of the average temperature in the interior of the star. (9)

(c) On 9 March 2011 the Voyager probe was 116.406 AU from the Sun and moving at 17.062 km/s. Determine the type of orbit the probe is on? What is the apparent magnitude of the Sun as seen from Voyager? (6)

6. (a) What is the meaning of differential rotational of Milky way galaxy? Obtain the expression for the Oort's constants and discuss their significance. (9)

(b) Cepheids are very bright variable stars whose mean absolute magnitudes & are functions of their pulsation periods given by $M = -1.21 - 2.88 \log_{10} P$.

P.T.O.