

- Use of non-programmable calculators is allowed.
- Draw neat labelled diagrams wherever required.

Given: $G = 6.67 \times 10^{-11} \text{ m}^3/(\text{kg}\cdot\text{s}^2)$, $M_\odot = 2 \times 10^{30} \text{ kg}$, $L_\odot = 3.839 \times 10^{26} \text{ W}$, $R_\odot = 6.96 \times 10^8 \text{ km}$,
 $m_H = 1.66 \times 10^{-27} \text{ kg}$, $k = 1.38 \times 10^{-23} \text{ J/K}$, $1 \text{ AU} = 1.5 \times 10^8 \text{ km}$, $m_p = 9.1 \times 10^{-31} \text{ Kg}$, $h = 2.8 \times 10^{-34} \text{ m}\cdot\text{Kg}$,
 $1 \text{ yr} = 3.15 \times 10^7 \text{ s}$, $c = 3 \times 10^8 \text{ m/s}$, $1 \text{ pc} = 3.08 \times 10^{16} \text{ m}$

Q1. Answer any Eight. Three marks each.

- Assume the density of the Sun is $1.53 \times 10^3 \text{ kg m}^{-3}$ and the Rosseland mean opacity is $0.217 \text{ m}^2 \text{ kg}^{-1}$. How many steps does a ray of light originating at the centre need to take to escape the Sun? (Assume the density and opacity is constant throughout the star).
- For a B0 star ($M = 3$), we observe an apparent magnitude $m = 10$. What is the distance to the star? $F = \frac{L}{4\pi d^2}$
- What is the Schwarzschild radius of a black hole having a mass of $100 M_\odot$?
- What is cosmic microwave background radiation?
- The luminosity of Vega is $40.12 L_\odot$ and its radius is $2.36 R_\odot$. What is the effective temperature of the sun and what is the wavelength corresponding to it? $R_\odot = \frac{a^2 \theta_m}{2 \times 60 \times 10^{-2}}$
- What are the various layers of the solar atmosphere?
- Explain the expected end states of open, closed, and flat universes.
- What are the different types of supernovae? Explain the various categories.
- In its rest frame, a galaxy produces a hydrogen emission line of wavelength $\lambda_{\text{rest}} = 21 \text{ cm}$. On Earth, this emission line is observed to have a wavelength of $\lambda_{\text{obs}} = 22 \text{ cm}$. What is the redshift and radial velocity of the galaxy?
- What is inflation?

Q2. Answer any Four. Five marks each.

- ζ -Phe is a 1.67-day spectroscopic binary with nearly circular orbits. Maximum measured Doppler shifts of the brighter and fainter components of the system are 121.4 km/s and 247 km/s , respectively. Find the quantity ' $m \sin^3 i$ ' for each star.
- Assuming mass the Sun loses no mass during its evolution. What would be its radius as a white dwarf and a neutron star? What is the fate of the sun? (Assume $Z/A = 0.5$).
- Explain the various types of galaxies in the Hubble Tuning Fork Diagram.
- Take a beam of light passing through a gas cloud. State the equation of radiative transfer. If $I_{\lambda,0}$ is the initial intensity, then what is the final intensity of the light for a constant source function? What happens when there is no source function? Suppose gas has a source function $S_\lambda = 2 I_{\lambda,0}$. If the optical depth is 1, then what is the intensity of the emergent beam?
- What are various sources of opacity in the photosphere of a star?

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Daniel F McAuley



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