B.Sc. 6th Semester (Honours) Examination, 2025 (CBCS)
Subject : Physics
Course : DSE-4
(Astronomy and Astrophysics)

Time: 3 Hours

Full Marks: 60

The figures in the margin indicate full marks.

*Candidates are required to give their answers in their own words
as far as applicable.*

Group-A

1. Answer *any ten* questions from the following: 2×10=20

   (a) Apparent magnitude of a star is observed to be + 3.3 and its parallax is 0.025″. Find absolute magnitude of that star.

   (b) Sketch the diurnal circles of stars as seen by an observer at the North Pole. Which stars are circumpolar for this observer?

   (c) Why does the length of an apparent solar day vary throughout the year?

   (d) Estimate the radius of a typical star in terms of the radius of the Sun. It is given that the star's temperature is two-thirds that of the Sun and its luminosity is 100 times the Sun's luminosity.

   (e) Calculate the diffraction limit of resolution (in arc seconds) of a telescope of diameter 5 m for $\lambda = 457$ nm.

   (f) Mention two advantages of CCDs over Photomultiplier Tubes as detector.

   (g) What do you mean by local thermodynamic equilibrium in a star?

   (h) Schematically show the variation of temperature with height in Solar Atmosphere.

   (i) For a typical sunspot, plasma speed is $1 \, \text{kms}^{-1}$ with a length scale 10^4 km. Magnetic diffusivity in solar photosphere is about $10^4 \, \text{m}^2\text{s}^{-1}$. Estimate the value of magnetic Reynolds number.

   (j) Distinguish between terrestrial planets and outer planets in solar family.

   (k) What do you mean by main sequence stars?

   (l) Define local standard of rest and peculiar velocity of a star.

   (m) State Hubble's Law for the expanding Universe and explain.

   (n) State the concept of Cosmic Distance Ladder.

   (o) From the present value of Hubble constant (70 km/sec/Mpc), estimate the age of the Universe.

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Group-B

2. Answer *any four* questions from the following: 5×4=20

   (a) Explain the horizontal coordinate system used in astronomy, showing the horizontal coordinates of a star on a celestial sphere for an observer at latitude 30°N.

   (b) Make an order of magnitude estimate of the average temperature in the interior of the Sun using Virial Theorem, assuming the Sun is made up of Hydrogen and its interior is in thermal equilibrium. Mass and Radius of the Sun are of the order of 10^{30} kg and 10^6 km respectively. Take gravitational constant $G \approx 10^{-10}$, Boltzmann Constant $\approx 10^{-23}$ and mass of Hydrogen atom $\approx 10^{-27}$ in SI units.

   (c) Give reasons for the following : (i) Ionized metal lines are the predominant feature of stars like the Sun (ii) Stars having narrow and sharp spectral lines have larger radii and lower temperature. 3+2

   (d) Why does the planetary system take the form of a disc? Explain with nebular model of solar system formation.

   (e) Distinguish between population I and II in terms of metallicity. Explain the origin of different metallicity of population I and population II stars. 2+3

   (f) In Type-1a supernova, white dwarfs explode in fixed luminosity. There was a Type-la supernova in Galaxy A with an apparent magnitude of m = – 4 at peak. Another Type-1a supernova went off in Galaxy B and had an apparent magnitude of m = + 16. Distance of the Galaxy A is 10^4 pc. How far away is Galaxy B?

Group-C

3. Answer *any two* questions from the following: 10×2=20

   (a) Define Luminosity and Flux of a star. Obtain a relation between two. If the apparent magnitudes of the component of a binary star are m and n and total apparent magnitude of the system is l, then show that $l = -2.5 \log_{10}(10^{-2n/5} + 10^{-2m/5})$. Explain the terms space velocity and proper motion of a star. 2+2+1+3+2

   (b) How does the atmosphere affect astronomical observation? Briefly explain. Compare the light gathering powers of the pupil of the dark adopted human eye (diameter = 5 mm) and a 50 cm diameter reflector. If the eye can just see a star of apparent magnitude + 6, what will be the maximum apparent magnitude that can be observed with the above reflector? 5+2+3

   (c) What are the sunspots? Explain why the temperature of sunspots is lower than their surroundings. Sketch the Butterfly diagram and explain its significance. 2+3+5

   (d) State de Vaucouleur's Law for the luminosity distribution of elliptic galaxies. Show that the total luminosity of a galaxy with effective radus R_e which satisfies the de Vaucouleur's Law is given by $L \approx 7.2\pi I_e R_e^2$, where you can use $\int_0^\infty dx\, x^7 e^{-x} = 7!$ where I_e is the brightness at the isophote that encloses a region emitting half of the total luminosity of the galaxy. What are the observational features of elliptical and spiral galaxies? 2+3+5

B.Sc. 6th Semester (Honours) Examination, 2025 (CBCS)

SH-VI/PHSH/DSE-4/25

Subject : Physics

Course : DSE-4

(Applied Dynamics)

Time: 2 hours

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as applicable.

Full Marks: 40

1. Answer *any five* questions:

   2×5=10

   (a) Define a dynamical system. Give two examples of first order dynamical systems.

   (b) Define fixed point of a dynamical system.

   (c) How do you define a fluid?

   (d) What is the shear stress?

   (e) What do you mean by flow dimensionality?

   (f) Define correlation dimension in context of Chaos theory.

   (g) What is the fractal dimension?

   (h) Compute the fractal dimension of Sirpinski.

2. Answer *any two* questions:

   5×2=10

   (a) Point out the difference between the steady flow and the unsteady flow. Describe uniform and non-uniform flow.

   2+3

   (b) (i) For a dynamical system, when a fixed point is called an attractor and when is it called a repeller? Between attractors and repellers, which fixed point would be stable?

   (ii) What is a phase space?

   (1+1+2)+1

   (c) (i) Find all the fixed points of $\dot{x} = x^2 - 1$ and classify their stability.

   (ii) What is a discrete dynamical system?

   (iii) What is the logistic map?

   2+1+2

   (d) Explain the Sinai Billiard Model? State some of its applications.

   3+2

3. Answer *any two* questions:

   10×2=20

   (a) (i) Construct the logistic population growth model equations.

   (ii) How is the logistic model different from the exponential growth model?

   (iii) Consider a population of 1000 people. At the onset, one person catches a flu. From the logistic model, how many people will contract the flu after 10 days? Given logistic growth constant is 0.603.

   5+1+4

(b) Define stream line, streak line and path line. Do they coincide under any condition? Explain.

$(3+3+3)+1$

(c) (i) What is Diffusion Limited Aggregation (DLA)?

(ii) What is the cobweb iteration? What are the steps to perform the cobweb iteration?

$5+(3+2)$

(d) (i) Explain the following properties of fluids—

(1) viscosity (2) thermal conductivity (3) mass diffusivity.

(ii) What is inviscid flow?

$(3+3+3)+1$

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