2023

PHYSICS

(Honours Elective)

Paper : PHY–HE–6046

(Astronomy and Astrophysics)

Full Marks : 80

Time : Three hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions : 1×10=10

   (a) What is Stellar Parallax ?

   (b) Write the sequence of classification of stars.

   (c) What is the most basic property of a star that determines its location on the main sequence ?

(d) Define an asteroid.

(e) Will solar time and sidereal time differ if the difference in the longitudes of two places is equal to the difference in time ?

(f) Where does the star formation take place in our galaxy ?

(g) What is cosmic microwave background radiation ?

(h) What is the shape of Kuiper belt ?

(i) What does *f*-number represent in a telescope ?

(j) What is Zenith point ?

2. Answer the following questions : 2×5=10

(a) Solar corona is observed only during total solar eclipse. Why ?

(b) Express 1 January, 2023 in Julian Date.

(c) Write declination δ of

(i) Celestial North pole

(ii) Celestial South pole

(iii) Zenith

(d) State the cosmological principle.

(e) The apparent magnitude of full Moon is −12·5 and that of Venus is −4. Which one is brighter and how much ?

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

(a) Parallax of Barnard's star is 0.522. Calculate its distance in parsec, light year, astronomical unit, mile and kilometre. 1+1+1+1+1=5

(b) Sketch the Sun, and identify the corona, chromosphere, photosphere, convection zone, radiation zone and core. Explain why the temperature of the chromosphere increases with height. 3+2=5

(c) The mass of Sirius B is thrice that of the Sun. Find the ratio of luminosity and difference in their absolute magnitude. Taking the absolute magnitude of the Sun as 5, find the absolute magnitude of Sirius B. 1+2+2=5

(d) Explain *one* method used for determination of distance of nearby celestial bodies.

(e) Define luminosity and radiant flux. Using Stefan-Boltzmann law of radiation, obtain the ratio of radii R_1 and R_2 of two stars with surface temperatures T_1 and T_2 and absolute magnitudes M_1 and M_2 respectively. 2+3=5

(f) Explain the concept of distance ladder.

4. Answer ***any four*** questions from the following : 10×4=40

(a) Sketch the H–R diagram showing all groups of stars. Show the location of the Sun on the diagram. What information does the H–R diagram provide about stars? 6+1+3=10

(b) What are galaxies? Explain the origin and evolution of galaxies. How are they classified? Draw a schematic view of the Hubble galaxy classification. What are the main differences between lenticulars and spirals? 1+2+1+3+3=10

(c) Explain the terms ecliptic, North and South celestial pole, horizon, celestial equator, latitude, longitude, declination, right ascension and hour angle. Draw a celestial sphere and show the positions of above mentioned terms in the celestial sphere. 5+5=10

(d) Derive Virial theorem and find the internal energy of a Star. 6+4=10

(e) (i) Discuss various parts of Milky Way, Stellar populations and motions of Stars in the Milky Way. 5

(ii) Define active galaxies. Mention the characteristics of active galaxies. 2+3=5

(f) Discuss different stages of the evolution of a star.

(g) What is meant by resolving power of a telescope? Explain the Rayleigh criterion for resolution. Calculate the diffraction limit of resolution of a 3*m* telescope for wavelength 600*nm*. 2+5+3=10

(h) Write short notes on ***any two*** of the following : 5×2=10

(i) Carbon-nitrogen cycle

(ii) White dwarf

(iii) Oort's cloud

(iv) Neutron star

(v) Oscillating universe

2023

PHYSICS

(Honours Elective)

Paper : PHY–HE–6056

(Classical Dynamics)

Full Marks : 80

Time : Three hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions : 1×10=10

   (a) What is conservative force ? Give examples.

   (b) A gas particle is moving inside a sphere, what will be the type of the constraint in it ?

   (c) What will be the number of generalized coordinates of a system of N particles having k constraints of motion ?

(d) Calculate the potential energy function associated with the force

$\vec{F} = -yz\hat{i} - zx\hat{j} - xy\hat{k}$.

(e) Write down the equation of stable equilibrium of system executing small oscillations.

(f) Under what condition Galilean transformation reduces to Lorentz transformation ?

(g) Justify that the earth is not an inertial frame.

(h) State the basic postulates of relativity.

(i) What is critical velocity of a fluid ? Write down its expression in terms of Reynold's number.

(j) Define terminal velocity of an object falling through a fluid.

2. Answer the following questions : 2×5=10

(a) What are generalized coordinates ? If a generalized coordinate has the dimension of momentum, what would be the dimension of generalized velocity ?

(b) Write the Lagrangian of a charged particle in an electromagnetic field, explaining each term.

(c) Explain : (i) normal modes of vibration; (ii) normal coordinates and (iii) normal frequencies of a system which undergoes small oscillations.

(d) 1 *kg* of a substance is fully converted into energy. Calculate the amount of energy produced.

(e) Show that the velocity of flow is inversely proportional to the area of cross-section of the tube.

3. Answer the following : ***(any four)*** 5×4=20

(a) Show that the path of a charged particle moving perpendicular to an uniform electric field is parabolic in nature.

(b) Write down the Lorentz transformation equations and obtain Lorentz-Fitzgerald contraction formula.

(c) A massless spring of force constant k has masses m_1 and m_2 attached to its two ends. The system rests on frictionless horizontal plane. Show that the angular frequency of the system is $\sqrt{\frac{k}{\mu}}$ where $\mu = \frac{m_1 m_2}{m_1 + m_2}$.

(d) What is relativistic energy ? Show that the relativistic energy E of a particle is given by is $E^2 = p^2c^2 + m^2c^4$.

(e) Explain relativistic time dilation. A certain particle has a life time of 10^{-6} *sec* when measured at rest. How far does it go before decaying if its speed is $0.9c$ when it is created (c is the velocity of light in free space) ?

(f) Obtain the equation of continuity for an incompressible fluid. An incompressible fluid is flowing through a pipe. If the diameter of the pipe is doubled, what change will occur to the velocity of the fluid ?

4. Answer the following : ***(any four)*** 10×4=40

(a) Obtain Lagrange's equation of motion from D'Alembert's principle. Consider a particle of mass m moving in a plane in a central force field. Write its Lagrangian in plane polar co-ordinates. Write the equations of motion and obtain the differential equation of the orbit. 5+5=10

(b) Derive Hamilton's canonical equation of motion from Hamilton's principle of least action. A mass m is suspended by a massless spring of spring constant k. The suspension point is pulled upwards with constant acceleration a_0. Find the Hamiltonian of the system and Hamilton's equations of motion. Also find the equation of motion of the system. 5+5=10

(c) Deduce Newton's second law of motion from Hamilton's principle. Masses m and $2m$ are connected by a light inextensible string which passes over a pulley of radius a. Write the Lagrangian and find the acceleration of the system. 5+5=10

(d) Derive the velocity addition theorem using four vectors. A particle of rest mass $1.67 \times 10^{-27} kg$ moves with a velocity $c/\sqrt{2}$. Calculate its relativistic momentum, kinetic energy and total energy. 6+4=10

(e) Establish Einstein's mass-energy equivalence principle $E = mc^2$. A pion decays into a muon and a neutrino. Show that momentum of muon is given by $p_\mu = \frac{c\left(m_\mu^2 - m_\pi^2\right)}{2m_\pi}$. 6+4=10

(f) State and explain relativistic transverse Doppler effect. Explain blue shift and red shift in Doppler effect. Calculate the wavelength shift in the relativistic Doppler effect for the frequencies H_α line (6563 $\AA$) emitted by a star receding from the earth with a relative velocity $0.1c$. Is the classical result (first order) a good approximation? 2+3+5=10

(g) Derive Poiseuille's equation for the rate of flow of fluid through a capillary tube. A tube of $0.1\,cm$ in diameter and $40\,cm$ long has to deliver $20\,kg$ water in $25\,min$. Calculate the constant pressure head to be maintained. The coefficient of viscosity for water is $8.9 \times 10^{-4} N\text{-}s\text{-}m^{-2}$. 6+4=10

(h) What is Reynold's number? Mention various range of values of Reynold's number for different types of flow of fluid. Derive the Navier-Stokes equation for flow of a viscous fluid. 1+3+6=10
