Time: 3 hrs. **M. M.: 100**

N.B.:

1. **All** questions are **compulsory**.
2. **Figures** to the **right** indicate **full** marks.
3. Draw **neat** diagrams wherever **necessary**.
4. Symbols have usual meaning unless otherwise stated.
5. Use of **non-programmable** calculator is allowed.

Constants: Planck's constant (h) = 6.64×10^{-34} J-s;
Mass of an electron (m_e) = 9.10×10^{-31}Kg = 0.00055 amu
Charge on electron (e) = 1.60×10^{-19} C
Speed of light (c) = 3×10^8 m/s
1 eV = 1.60×10^{-19} J

Q1. Attempt any **two**

(i) Discuss Gamow's theory of α-decay? **10**

(ii) (A) Explain how the velocity of α-particles is determined using magnetic spectrograph? **10**
(B) Write note on short range alpha particles.

(iii) Describe the detection of neutrino using Cowan and Reines experiment. **10**

(iv) Explain three different types of β-decay. Derive the energetic for K-capture process. **10**

Q2 Attempt any **two**

(i) Obtain expression for binding energy of a nucleus based on liquid drop model. **10**

(ii) What is γ ray spectra? Explain the selection rules in case of γ -decay. Also discuss the phenomenon of internal conversion. **10**

(iii) What are mass parabolas? For odd A nuclei, derive expression for the charge and mass of the most stable isobar. **10**

(iv) Describe Mossbauer effect using its experimental set up. **10**

Q3 Attempt any **two**

(i) What is natural fusion? Explain energy productions in stars using carbon cycle. **10**

(ii) Explain the Nuclear cycle in a thermal nuclear reactor and show how it leads to the Four factor formula. How does this formula get modified if the reactor fuel contains only U^{235} and no U^{238}? **10**

(iii) Explain construction and working of Van de Graff generator in detail with the help of schematic diagram. **10**

(iv) Describe the construction and working of Betatron. **10**

Q4 Attempt any **two**

(i) Summarize the important experimental properties of the deuteron. **10**

(ii) Explain meson theory of nuclear Force. Using Heisenberg's uncertainty principle, estimate the mass of meson. **10**

(iii) What are elementary particles? Give the basis of their classification. **10**

(iv) (a) State conservation laws for various properties of elementary particles. **10**

(b) Give the basic properties of neutrinos and antineutrinos.

Q5. Attempt any **four**

(i) Explain what is Specific ionization and Stopping power. **05**

(ii) Explain continuous β-particle spectra. **05**

(iii) Write a note on nuclear isomerism. **05**

(iv) What are mirror nuclei? For the mirror nuclei, $^{15}_{7}N$ and $^{15}_{8}O$, calculate Coulomb coefficient. **05**

Given: $M(^{15}_{7}N) = 15.000108$ amu, $M(^{15}_{8}O) = 15.00307$amu,
$m_n = 1.008665$ amu, $m_p = 1.007825$

(v) If the fission process starts with the 3000 neutrons and the multiplication factor k = 1.05, calculate the number of neutrons present in the tenth generation. **05**

(vi) The radius of dees in the cyclotron is 35 cm and magnetic field is 3000 Gauss. What would be the velocity and energy of protons? **05**

Given: $m_{p=}$ 1.67×10^{-27}Kg, $q = 1.6 \times 10^{-19}$C.

(vii) Write a short note on photon. **05**

(viii) Explain qualitatively the Quark model. **05**

Time: 3 hrs. M. M.: 100

N.B.:

1. **All** questions are **compulsory**.
2. **Figures** to the **right** indicate **full** marks.
3. Draw **neat** diagrams wherever **necessary**.
4. Symbols have usual meaning unless otherwise stated.
5. Use of **non-programmable** calculator is allowed.

Constants: Velocity of Light: $c = 3 \times 10^8$ meter per second
Planck's Constants: $h = 6.63 \times 10^{-34}$ joule second

Q1. Attempt any **two**

(i) Explain the invariance of physical law. Obtain the Galilean transformation for velocity and acceleration and hence shows that force remain invariant under Galilean transformation. **10**

(ii) Explain the length contraction hypothesis. Derive necessary equation. Obtain the volume of cube, when moving with velocity V along one of its edges is parallel to X-axis. The proper length of each edge of cube is l_0. **10**

(iii) Derive the inverse Lorentz transformation equations. **10**

(iv) Using Lorentz transformation equations of space time show that space difference in one frame converted to time difference in another frame and time difference in one frame is converted to space difference. **10**

Q2 Attempt any **two**

(i) Derive Lorentz transformation equations for velocity. Using it show that the velocity of light remains the same in all inertial frames of reference. **10**

(ii) With the help of Minkowski space time diagram explain Relativity of simultaneity and length contraction. **10**

(iii) Derive the relativistic aberration formula using the Lorentz transformation of velocity. **10**

(iv) Derive Lorentz transformation equations for components of acceleration. **10**

Q3 Attempt any **two**

(i) Show that the mass of a particle moving with a speed u is to be defined by $m = \frac{m_o}{\sqrt{1-\frac{u^2}{c^2}}}$ **10**

(ii) Show that, in a region in which there is a uniform magnetic field, a charged particle entering at right angles to the field movies in a circle whose radius is proportional to the particle's momentum. Hence compute the radius, both classically and relativistically, of a 10 MeV electron moving at right angles to a uniform magnetic field of 2 Wb/m^2. **10**

(iii) Using relativistic definition of energy and momentum show that **10**

a) $E^2 = p^2c^2 + m_o^2c^4$

b) $u = \frac{dE}{dp}$

(iv) Obtain the Lorentz transformations of momentum and energy. **10**

Q4 Attempt any **two**

(i) Show that the electric field of uniformly moving point charge in an inertial frame of reference loses its spherical symmetry. **10**

(ii) Derive the expression for force and fields near a current carrying wire. **10**

(iii) Derive the transformation equation for electric field $\vec{E}$ using Lorentz transformation equation for force. **10**

(iv) Show that the Maxwell's equations of electrodynamics are invariant under Lorentz transformation. **10**

Q5. Attempt any **four**

(i) The area of disc in its rest frame is $1m^2$. The disc appears distorted to an observer moving with speed 0.8 c with respect to rest frame along the plane of disc. Find the area measured by an observer. **05**

(ii) Two events separated by spatial distance of $9 \times 10^9 m$ are simultaneous in one inertial frame. What will be the time interval between these two events in another frame moving with velocity 0.8c. **05**

(iii) Write a short note on Twin paradox. **05**

(iv) A source of light of wavelength 6000 AU is approaching an observer with a speed of 0.8c. Find the wavelength of light as observed by the stationary observer. **05**

(v) The earth receives the radiant energy from the sun at the rate of $1.34 \times 10^3\ watts/m^2$. At what rate is the sun losing rest mass due to its radiation? The sun's rest mass is now about $2 \times 10^{30} Kg$. **05**

(vi) Find the mass and kinetic energy of photon of wavelength 5000Å. Take Planck's constant $h = 6.63 \times 10^{34}\ Js$. **05**

(vii) State the postulates of General theory of relativity and explain principle of equivalence **05**

(viii) Obtain the expressions for ρ and $\vec{j}$ in terms of ρ_0. Hence show that $\rho = \left(\frac{\rho_0}{m_0}\right) m$; $\vec{j} = \left(\frac{\rho_0}{m_0}\right) \vec{p}$ **05**

Time: 3 hrs. **M. M.: 100**

N.B.:

1. **All** questions are **compulsory**.
2. **Figures** to the **right** indicate **full** marks.
3. Draw **neat** diagrams wherever **necessary**.
4. Symbols have usual meaning unless otherwise stated.
5. Use of **non-programmable** calculator is allowed.

Q1. Attempt any **two**

(i) State Kepler's three laws of planetary motion and prove second and third laws. **10**

(ii) Show that when body moves in a central force field its motion is confined to a plane. **10**

(iii) Obtain the equation of motion of a particle of mass m as related to the rotating earth. **10**

(iv) A starred system rotates with a variable angular velocity ω with respect to inertial system fixed in space. Show that **10**

$$\frac{dr}{dt} = \frac{d^*r}{dt} + \boldsymbol{\omega} \times \mathbf{r}$$

Hence obtain the Coriolis theorem.

Q2 Attempt any **two**

(i) a) What is virtual displacement? **10**

b) State and derive an expression for the principle of virtual work.

(ii) a) Define the generalized force Q_k. Using that definition, show that, **10**

$$Q_k = -\frac{\partial V}{\partial q_k}$$

Where V is potential and q_k are generalized coordinates.

b) Show that, for Cartesian coordinates x_i and general coordinates q_k,

$$\frac{\partial \dot{x}_i}{\partial \dot{q}_k} = \frac{\partial x_i}{\partial q_k}$$

(iii) Consider a particle constrained to move on the inner surface of the cone with half angle α. Set up the Lagrangian and get the equations of motion. **10**

(iv) a. What is canonical momentum? For a Lagrangian given by **10**

$$L = \frac{1}{2}m(\dot{x}^2 + \dot{y}^2 + \dot{z}^2) - q\phi(x, y, z) + q\left(\vec{A} \cdot \vec{v}\right)$$

b. Calculate all the components of canonical momentum.

c. Is this canonical momentum a conserved quantity? Give reason to your answer.

Q3 Attempt any **two**

(i) Derive Euler's equation of motion for a rigid body .Discuss its cases for spin, moment of inertia and angular velocity is at constant ,zero and nonzero **10**

(ii) Obtain an equation of continuity in kinematics of moving fluid .Write the equation if the fluid is incompressible **10**

(iii) Derive Bernoulli's theorem from conservation of linear momentum and energy. Write the meaning of every term in its equation **10**

(iv) What is an Ideal fluid. Obtain the Eulers equation equation of motion for an ideal fluid. state the assumptions **10**

Q4 Attempt any **two**

(i) What is an Anharmonic oscillator? Write down the general expression for restoring force indicating harmonic and anharmonic terms.Draw potential energy curves for (i) $\propto < 0 , K > 0$ (ii) $\propto < 0 , K < 0$. Infer on the confined motion in each case, If potential energy of Anharmonic oscillator is $V(x) = K (\frac{x^2}{2} + \frac{\propto x^4}{2})$. Where $K \rightarrow spring\ constant$, $\alpha \rightarrow anharmonic\ coefficient.$ **10**

(ii) What is logistic map? Find its fixed points, showthat the fixed point x=0 is an attractor for $\lambda < 1$ and a repeller for $\lambda > 1$. **10**

(iii) Obtain reduced Duffing's equation by suitable rescalling. Discuss numerical solutions of Duffing's equation for γ =0.1, f = 0.5 graphically showing odd and even harmonics. Explain the mechanical hysteresis. **10**

(iv) Show that the undamped duffing's equation $\ddot{x} + x + x^3 = f \cos wt$ can have the exact solution $x(t) = A_0 \cos\frac{wt}{3}$. find the conditions under which such simple subharmonic solution occurs. **10**

Q5. Attempt any **four**

(i) Define central force. Explain types of central forces. **05**

(ii) Interpret the various terms involved in the Coriolis's theorem **05**

(iii) Set up the Lagrangian for a simple pendulum. Using that derive the equation of motion. **05**

(iv) Define constraints. Give three examples **05**

(v) Consider a liquid flowing through horizontal tube of non-uniform cross-section. The pressure is 1600 N/m^2 at a point where the velocity of flow is 0.5 N/m^2 what is the Velocity of flow at a point where pressure is 1000 N/m^2 .Density of liquid is uniform and is equal to 1000 kg/m^3 . **05**

(vi) A rigid body consists of three particles of masses 2, 1 and 4 units located at (1, −1,1), (2,0,2) and (−1,1,0) respectively. Determine the elements of the moment of inertia matrix for the rigid body. **05**

(vii) Write down three properties of deterministic chaos **05**

(viii) What is phase space diagram? Plot phase space diagram for one - dimentional damped oscillator and driven oscillator. **05**
