[This question paper contains 4 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1029 **D**

Unique Paper Code : 2222011101

Name of the Paper : Mathematical Physics – I

Name of the Course : **B.Sc. Hons. Physics**

Semester : I

Duration : 3 Hours Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question **1** is Compulsory.
3. Attempt any **four** questions from question Numbers **2-6**.
4. **All** questions carry equal marks.

1. (a) Find the value of the Jacobian $J\frac{(u,v)}{(r,\theta)}$ where $u = x^2 - y^2$ and $v = 2xy$ and $x = r\cos\theta$, $y = r\sin\theta$.

   (b) In what direction from the point (1,3,2) is the directional derivative of $\Phi = 2xz - y^2$, a maximum?

(c) Evaluate $\oiint \vec{r}.\hat{n}\, ds$ where S is a closed surface.

(d) Express $\vec{r}, \hat{r}$ and $\vec{a}.\hat{r}$ in index notation.

(e) Show that following equation is exact and solve it:

$$(y \cos x + \sin y + y)dx + (\sin x + x \cos y + x)\, dy = 0$$

(f) Refer to the Probability distribution given below:

X:	−3	6	9
P(X=x)	1/6	1/2	1/3

Find E(X) and $E((2X+1)^2)$. (3×6)

2. (i) Show that following equation is inexact and then solve it :

$$(2x \log x - xy)\, dy + 2\, y\, dx = 0$$ (6)

(ii) A certain radioactive material is known to decay at a rate proportional to the amount present. If initially there is 50 milligrams of the material present and after two hours it is observed that the material has lost 10 percent of its original mass. With the help of the differential equation $dN/dt = kN$, N being the amount of material present at time t, find (a) an expression for the mass of the material remaining at any time t (b) the mass of the material after 4 hours. (6)

(iii) Solve by the method of Undetermined Coefficients :

$d^2y/dx^2 + 2\,dy/dx + y = x - e^{-x}$ (6)

3. (i) Solve the given differential equation :

$$\frac{dy}{dx} + 2y\tan x = \sin x$$

given that $y = 0$ when $x = \pi/3$. (6)

(ii) Solve by the method of Variation of parameters:

$d^2y/dx^2 + a^2 y = \tan ax$ (6)

(iii) Solve the differential equation:

$x^2 d^2y/dx^2 - 4x\,dy/dx + 6y = 42/x^4$ (6)

4. (i) Show that

$\nabla^2 r^n = n(n+1)r^{n-2}$ where $r^2 = x^2 + y^2 + z^2$ (4)

(ii) Show that

$$\vec{A} = \left(6xy + z^3\right)\hat{i} + \left(3x^2 - z\right)\hat{j} + \left(3xz^2 - y\right)\hat{k}$$

is irrotational. Find Φ such that $\vec{A} = \vec{\nabla}\Phi$ (6)

(iii) Prove $\vec{\nabla}\times\left(\vec{\nabla}\times\vec{A}\right) = \vec{\nabla}\left(\vec{\nabla}.\vec{A}\right) - \nabla^2\vec{A}$. (8)

5. (i) Verify the divergence theorem for

$$\vec{A} = 4x\hat{i} - 2y^2\hat{j} + z^2\hat{k}$$

taken over the region bounded by $x^2 + y^2 = 4$, $z = 0$ and $z = 3$. (9)

(ii) Using Stake's theorem, evaluate

$$\int (x + 2y)dx + (x - z)dy + (y - z)dz$$

over the contour C, where C is the boundary of triangle bounded with vertices (2,0,0), (0,3,0) and (0,0,6) oriented in anticlockwise direction and S is the surface of the plane

$$\frac{x}{2} + \frac{y}{3} + \frac{z}{6} = 1$$ (9)

6. (i) Show that scalar product of two vectors is invariant under rotation of axes. (4)

(ii) Find an expression for the mean and variance of the Binomial distribution. (8)

(iii) If $\vec{F} = 2y\hat{i} - z\hat{j} + x^2\hat{k}$.

and S is the surface $y^2 = 8x$ in the first octant bounded by the plane $y = 4$ and $z = 6$, evaluate

$$\iint \vec{F}.\hat{n}\, dS.$$ (6)

[This question paper contains 8 printed pages.]

Your Roll No..............

Sr. No. of Question Paper : 1048 **D**

Unique Paper Code : 2222011102

Name of the Paper : Mechanics

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

Semester : I

Duration : 3 Hours Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.

2. Use of non-programmable scientific calculators are allowed.

3. **All** Questions carry equal marks.

4. Q. No. **1** is compulsory.

5. Answer any **four** of the remaining **five** questions.

P.T.O.

1. Attempt **all** parts of this question.

(i) A body of mass 1 kg and initial velocity 10 ms^{-1} is sliding on a horizontal surface. If the coefficient of kinetic friction between the body and the surface is 0.5, then find the work done by friction when the body has traversed a distance of 5 m along the surface. (3)

(ii) Consider circular orbits in a central force potential $U(r) = -kr^{-n}$ where $k > 0$ and $0 < n < 2$. If the time period of circular orbit of radius R is T_1 and that of radius 2R is T_2, find the value of

$\frac{T_2}{T_1}$. (3)

(iii) A nucleus initially at rest decays radioactively by emitting two particles, an electron with momentum 1.2×10^{-22} kg ms^{-1} and a neutrino at right angle to the electron with momentum 6.4×10^{-23} kg ms^{-1}. Find the direction and momentum of the recoiled nucleus. (3)

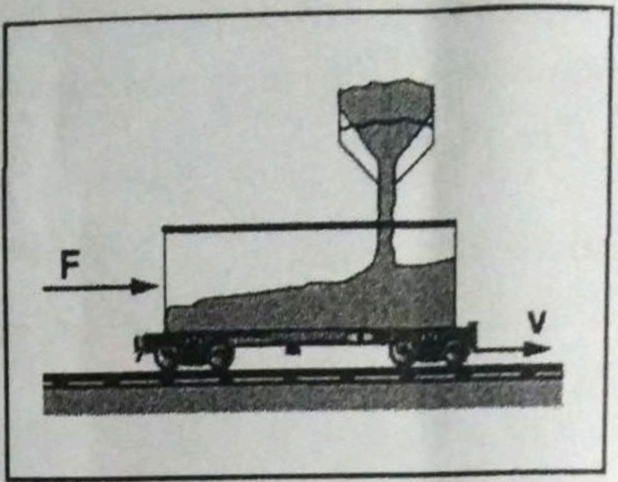
(iv) Three masses each of 2kg are situated at the vertices of an equilateral triangle whose sides measure 0.1 m each. Calculate the moment of inertia of the system and its radius of gyration with respect to an axis perpendicular to the plane determined by the triangle and passing through one of its vertices. (3)

(v) Calculate the speed of a 2 MeV electron, given that the rest mass of an electron is 0.5 MeV. (3)

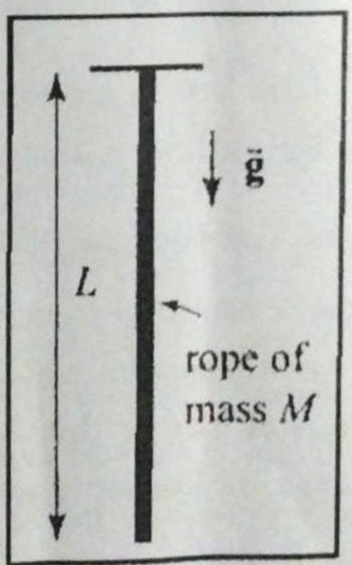
(vi) A bucket containing water is tied to one end of a rope and rotated about the other end in a vertical circle of radius 0.75 m. Find the minimum speed at the top to ensure that no water spills out. (3)

2. (i) Find the centre of mass of a right angled triangular sheet of mass M, base b, height h and small thickness t. (6)

(ii) Sand falls from a stationary hopper continuously on a freight car which is moving with uniform velocity v. The sand falls at the rate $\frac{dm}{dt}$. Find the force required to make the freight move with the same constant velocity v. Also prove that the power due to this force is twice the rate of increase of kinetic energy of the system. (6)



(iii) A rope of mass M and length L is suspended from a ceiling as shown in the figure. Find the tension in the rope as a function of the distance from the ceiling and hence show that the tension changes at a constant rate along the length of the rope. What is the tension in the rope at the upper end where the rope is fixed to the ceiling. (6)

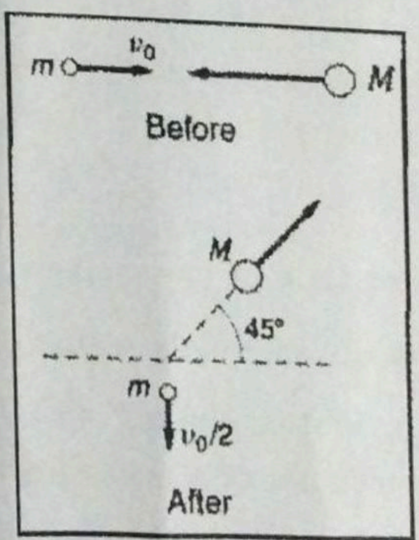


3. (i) A particle of mass m moves in one dimension along the positive x axis. It is acted on by a constant force directed towards the origin with magnitude B and an inverse square law repulsive force with magnitude $\frac{A}{x^2}$. Find the potential energy function U(x) and the equilibrium position x_0 of the particle. What is the frequency of small oscillations about x_0?

(6)

(ii) A particle of mass m and initial velocity v_0 collides elastically with a particle of unknown mass M coming from the opposite direction as shown in the diagram. After the collision, m has velocity $\frac{v_0}{2}$ at right angles to the incident direction, and M moves off in the direction shown in the figure. Find the ratio M/m.

(6)



(iii) A particle slides back and forth on a frictionless track whose height as a function of horizontal position x is given by $y = bx^2$ where $b = 0.92\ m^{-1}$. If the particle's maximum speed is $8.5\ ms^{-1}$, find the turning points of its motion. (6)

4. (i) Show that the total angular momentum of a system of particles about an axis of rotation is given by the relation $\vec{J} = \vec{J}_0 + \vec{J}_{c.m.}$, where $\vec{J}_0$ is the angular momentum of the centre of mass of the system about the given axis and $\vec{J}_{c.m.}$ is the angular momentum of the system about an axis parallel to the given axis passing through the centre of mass. (6)

(ii) A cylinder of radius R and mass M rolls without slipping down a plane inclined at angle θ. The coefficient of friction is μ. Determine the maximum value of $\theta = \theta_c$ for the cylinder to roll without slipping? What will be the acceleration of the cylinder as it rolls down the incline plane. (6)

(iii) A particle of mass 2 kg moves along a straight line given by the equation $y = \frac{x}{\sqrt{3}} + 3$, with a constant speed of $4ms^{-1}$. Find the angular momentum of the particle about the origin. (6)

5. (i) Consider two inertial observers O and O′ moving with relative speed v with respect to each other. Their coordinate axes (Cartesian) are parallel to each other, with the x direction being the direction of relative motion such that observer O′ is observed to move with velocity v along the positive x direction of observer O. The observers observe the motion of a particle. Starting with Lorentz transformations, determine the relation between the velocity of the particle as measured by the two observers. (6)

(ii) What are space-like, time-like and light-like events? In a certain inertial frame, two firecrackers go off at the same instant of time, separated by distance l. Are these two events spacelike, time-like or light-like? Explain. (6)

(iii) A bug crawls towards the rim with a constant speed v_0 along the spoke of a wheel that is rotating with constant angular velocity ω about a vertical axis. Find all the apparent forces acting on the bug. Find how far the bug can crawl before it starts to slip, given that the coefficient of static friction between the bug and the spoke is μ_s. (6)

6. (i) A clock is observed to move in an inertial frame O with velocity v. Two events take place at the

location of the clock, with the duration between these events measured to be $\Delta\tau$ by the clock. Between these two events, the clock moves past two identical clocks at rest in frame O. If the duration between these events is Δt as measured by these clocks, starting with Lorentz transformations, deduce a relationship between $\Delta\tau$ and Δt. (6)

(ii) Two spaceships approach each other, each moving with the same speed as measured by a stationary observer on the Earth. Their relative speed is 0.7c. Determine the velocities of each spaceship as measured by the stationary observer on Earth. (6)

(iii) A simple pendulum consisting of a mass m suspended by a string of negligible mass and length l is hanging from the ceiling of a tram car. The car is accelerating relative to the road with uniform acceleration of magnitude a. Analyzing the dynamics in the frame of reference of the car, derive an expression for the angle (relative to the vertical direction) at which the pendulum will be in equilibrium. What will be the time period of small oscillations of the pendulum about this equilibrium position? (6)

X 3

[This question paper contains 7 printed pages.]

Your Roll No..............

Sr. No. of Question Paper : 1069 **D**

Unique Paper Code : 2222011103

Name of the Paper : Waves and Oscillations (DSC 3)

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

Semester : I

Duration : 2 Hours Maximum Marks : 60

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.

2. Attempt **any four** questions in all.

3. **Question No. 1** is compulsory.

4. Use of non- programmable scientific calculator is allowed.

1. Attempt all questions. Each question carries equal marks. (3×5)

(a) Define simple harmonic motion (SHM). Prove that the principle of superposition holds in case of the Homogeneous Linear equations.

(b) Consider a mass ***m*** attached with two identical massless springs having spring constant ***k***, relaxed length a_0 and equilibrium length ***a*** each as shown in Fig. 1. Show that the frequency of transverse oscillation (under slinky approximation) is: $\omega = \sqrt{\frac{2k}{m}}$.

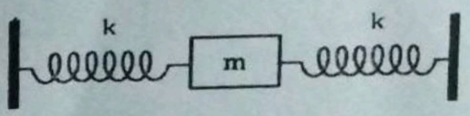


Fig. 1

(c) The equation of a damped harmonic oscillation is given by,

$$8\left(\frac{d^2y}{dt^2}\right) + 24\left(\frac{dy}{dt}\right) + 48\,y = 0$$

Find the frequency of the damped oscillations.

(d) A damped harmonic oscillator has the amplitude of 20 cm. It reduces to 2 cm after 100 oscillations each of the time period 4.6 s. Calculate its logarithmic damping constant. Compute the number of oscillations in which the amplitude drops by 50%.

(e) Distinguish between stationary and progressive waves.

2. (a) A uniform spring of length l has force constant k. The spring is cut into two pieces of unstressed lengths l_1 and l_2, where $(l_1/l_2) = (n_1/n_2)$. Express the force constants k_1 and k_2 of the two pieces in terms of k, n_1 and n_2. (5)

(b) Deduce an expression for the energy of a harmonic oscillator of mass m, amplitude a and angular frequency ω. At what value of the displacement kinetic and potential energies become equal? (5)

(c) An alternating emf of peak-to-peak value of 40 V is applied across the series combination of an inductor of inductance 100 mH, capacitor of capacitance 1μF and resistance 100Ω. Determine maximum value of current drawn by circuit its bandwidth and quality factor. (5)

3. (a) Two collinear simple harmonic motions of nearly equal frequencies and different amplitude are superimposed on each other. Find out the resultant equation and explain the formation of beats. (10)

(b) A point is under the influence of two simultaneous simple harmonic motion is mutually perpendicular directions given by $x = a \cos \pi t$, $y = a \cos \pi t/2$. Find the trajectory of the resulting motion of that point. (5)

4. (a) Show that for forced damped harmonic oscillator in steady state, the average power is equals to the average power dissipated by the system. (10)

(b) An object of mass 0.1 kg is suspended from a spring of force constant 100 Nm1. The frictional force acting on the object is 5v Newton, where v is its velocity. If a harmonic force F = 2 cos 20t is applied on this object calculate the steady state amplitude of the forced oscillation. (5)

5. (a) The string of length 3a under tension T has two equal masses places at a and 2a as shown in fig.2.

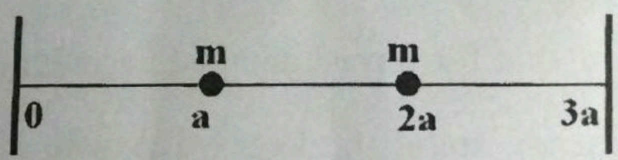


Fig. 2

Find out the normal mode of transverse and longitudinal vibrations using small- oscillation approximation. (10)

(b) Establish the classical wave equation $\frac{\partial^2 \psi}{\partial t^2} = v^2 \frac{\partial^2 \psi}{\partial x^2}$ by considering a harmonic wave travelling in a medium with velocity v. (5)

A

[This question paper contains 6 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1382 **C**

Unique Paper Code : 32221301

Name of the Paper : Mathematical Physics – II

Name of the Course : **B.Sc. (H) Physics**

Semester : III

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. Attempt **five** questions in all.
3. Q. No. **1** is compulsory.

1. Attempt any **five** questions : (5×3=15)

(a) Prove that even function can have no sine terms in its Fourier expansion.

(b) Determine whether the functions cos 2x and cos x are orthogonal or not in the interval $(0, 2\pi)$.

(c) Evaluate : $\int_0^{\pi/2} \cos^6\theta \, d\theta$.

(d) Find the value of $\Gamma\left(\frac{-5}{2}\right)$.

(e) Show that for integral values of n, $AJ_n(x) + BJ_{-n}(x)$ is not a general solution of Bessel equation of order n.

(f) Prove : $P_n'(1) = \frac{n(n+1)}{2}$.

(g) Find whether x = 1 is an ordinary, regular or irregular singular point of the given differential equation :

$$x^2(1-x^2)y'' + \frac{2}{x}y' + 4y = 0$$

(h) Determine whether or not $u(x, y) = 4e^{-3x}\cos 3y$ is a solution of given partial differential equation :

$$\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$$

2. (a) Find the Fourier series expansion of a periodic function given by : (10)

$$f(t) = \begin{cases} E_o \sin t, & 0 < t < \pi \\ 0, & \pi < t < 2\pi \end{cases}$$

(b) Evaluate : $\int_0^2 x(8 - x^3)^{1/3} dx$ (5)

3. Consider a periodic function f(x) of period 2π such that

$$f(x) = \pi - x, \ 0 < x < \pi$$

(a) Plot odd extension of f(x) in the range $(-3\pi, 3\pi)$. (3)

(b) Find its half-range Fourier Sine Series. (6)

(c) Show that $1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \ldots\ldots = \frac{\pi}{4}$ (3)

(d) Also, prove that $1 + \frac{1}{4} + \frac{1}{9} + \ldots\ldots = \frac{\pi^2}{6}$ (3)

4. Consider the following differential equation :

$$4x^2 y'' + 4xy' + (x^2 - 1)y = 0$$

(a) Find whether x = 0 is an ordinary, regular or irregular singular point. (3)

(b) Using Frobenius method, determine the roots of indicial equation and hence find the first solution. (4,5)

(c) Also, find the second solution. (3)

5. (a) Prove that orthogonality relation for Legendre polynomials is given by

$$\int_{-1}^{1} P_n(x)\, P_m(x)\, dx = \begin{cases} \dfrac{2}{2n+1}, & m = n \\ 0, & m \neq n \end{cases} \qquad (10)$$

(b) The generating function of Legendre polynomials is given by :

$$(1 - 2xt + t^2)^{-1/2} = \sum_{n=0}^{\infty} t^n\, P_n(x),$$

Using this generating function, prove that :

$$P_{n+1}(x) = \frac{2n+1}{n+1}\, x\, P_n(x) - \frac{n}{n+1} P_{n-1}(x) \qquad (5)$$

6. Given, $e^{\frac{x}{2}\left(t-\frac{1}{t}\right)} = \sum_{n=-\infty}^{\infty} t^n J_n(x)$

Verify that :

(i) $\cos(x\sin\theta) = J_0(x) + 2J_2(x)\cos2\theta + 2J_4(x)\cos4\theta + ...$

(ii) $\sin(x\sin\theta) = 2J_1(x)\sin\theta + 2J_3(x)\sin3\theta + ...$

Hence prove that :

$$J_n(x) = \frac{1}{\pi}\int_0^{\pi} \cos(n\theta - x\sin\theta)\,d\theta$$ (3,3,9)

7. Using the method of separation of variables, find the general solution of 2-D wave equation for the case of symmetrical circular membrane (radius = a):

$$\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial u}{\partial r}\right) = \frac{1}{c^2}\frac{\partial^2 u}{\partial t^2};\ c > 0$$

subject to the conditions :

$u(a, t) = 0$, $\left.\frac{\partial u}{\partial t}\right|_{t=0} = 0$ and $u(r, 0) = u_0(r)$ (15)

8. (a) Using the method of separation of variables, solve the following differential equation :

$$\frac{\partial u}{\partial x} = 4\frac{\partial u}{\partial y}.$$

when $u(0, y) = 8e^{-3y} + 4e^{-5y}$. (5)

(b) A homogeneous rod of conducting material of length 100 cm has its ends kept at zero temperature and the initial temperature is

$$u(x, 0) = \begin{cases} x, & 0 \le x \le 50 \\ 100 - x, & 50 \le x \le 100 \end{cases}$$

Using 1-D heat equation, find the temperature $u(x, t)$ at any time. (10)

[This question paper contains 8 printed pages.]

Your Roll No..............

Sr. No. of Question Paper : 1411 **C**

Unique Paper Code : 32221302

Name of the Paper : Thermal Physics

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

Semester : III

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. Attempt **five** Questions in all
3. Question No. **1** is compulsory.
4. Answer any **four** of the remaining **six**.

1. Attempt any **five** :

(a) Show that heat and work are path functions but their differences are point functions.

(b) Classify the following processes into reversible or irreversible processes and give their reasons

(i) isothermal expansion of gas

(ii) diffusion of gases

(c) A gas has the following equation of state :

$$P\left(V-\frac{a^4}{V}\right)=nRT$$

What is the work done by the gas when it is expanded isothermally?

(d) Two moles of an ideal gas expand isothermally to four times its initial volume. Calculate the entropy change in terms of R, the universal gas constant.

(e) The radius of argon atom is 0.128 nm. Calculate their mean free path at temperature 25°C and pressure 1 atmosphere. Given $K_B = 1.38 \times 10^{-23}$ JK.

(f) Calculate the deviation of van der Waals gas law from ideal gas law at the critical point.

(g) On the basis of third law of thermodynamics prove the unattainability of absolute zero temperature. (3×5=15)

2. (a) Give the mathematical form of the first law of thermodynamics and explain its significance. For an ideal gas, derive the relations

(i) $C_P - C_V = R/J$ for an isobaric process

(ii) $PV^\gamma = \text{Constant}$ for an adiabatic process

(b) A process for an ideal gas is defined by the relation $P = AT^b$. Calculate the isobaric coefficient of volume expansion (α) and isothermal compressibility (K).

(c) The volume of lg mole of a gas filled in a container at standard pressure (1×10^5 N/m^2) and temperature (0° C) is 22.4×10^{-3} m^3. The volume of the gas is reduced to half its original value by increasing the pressure. (i) isothermally (ii) adiabatically. In each case calculate the final pressure of the gas and amount of work done [$\gamma=1.40$ and R=8.3 J mol^{-1} K^{-1}]. (6,6,3)

3. (a) Show that the efficiency of all reversible heat engines operating between the same two temperatures is same.

(b) Give Kelvin Planck and Clausius statements of the second law of thermodynamics and hence discuss their equivalence.

(c) A reversible heat engine converts one fifth of the input heat into work. On reducing the temperature of the sink by 50°C, its efficiency is doubled. Find the temperatures of the source and the sink. (6,6,3)

4. (a) With the help of an example for each process, show that there is always an increase in entropy during an irreversible process while it remains constant during a reversible process. Hence, discuss Clausius inequality.

(b) Obtain an expression for change in entropy of an ideal gas having n moles in terms of pressure and temperature when it's thermodynamic state changes from (P_i, V_i, T_i) to (P_f, V_f, T_f).

(c) Calculate the change in entropy when 0.01 kg of water at 288 K is mixed with 0.02 kg of water at 313 K. Take specific heat of water as 4200 J kg^{-1} K^{-1}. (6,6,3)

5. (a) Define four thermodynamic potentials and hence derive Maxwell's thermodynamic relations from them.

(b) Using Maxwell's relations prove

$$(\partial Cv/\partial V)_T = T(\partial^2 P/\partial T^2)_V$$

Hence show that it is equal to zero for both ideal and van der Waals gases.

(c) Calculate the change in melting point of ice at STP, when it is subjected to a pressure of 90 atmosphere. For ice, density = 0.92 g/cm^3 and latent heat of fusion = 80 cal/g. (6,6,3)

6. (a) Derive the Maxwell's law of distribution of velocity. Discuss briefly its graphical representation.

(b) State and explain the law of equipartition of energy and hence show that the value of $\gamma = C_P/C_V$ for monoatomic, diatomic and triatomic gases are 1.66, 1.4, 1.33, respectively.

(c) Calculate the root mean square speed and most probable speed of a gas whose density is 1.4 g/litre at a pressure of 10^5 N/m^2. (6,6,3)

7. (a) Describe Joule-Thomson's porous-plug experiment. Derive an expression for Joule-Thomson's coefficient (μ) and inversion temperature for a real gas obeying van der Waals equation. Explain the significance of inversion temperature.

(b) Obtain the relation between the critical temperature, Boyles temperature and the temperature of inversion for a van der Waals gas. Also write law of corresponding state.

(c) The critical Temperature of CO_2 is 31°C and its critical pressure is 73 atmospheres. Assuming that CO_2 obeys van der Waals equation, compute the critical volume of CO_2. (6,6,3)

6

[This question paper contains 4 printed pages.]

Your Roll No..............

Sr. No. of Question Paper : 1429 **C**

Unique Paper Code : 32221303

Name of the Paper : Digital Systems and Applications

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

Semester : III

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. Attempt any **five** questions in all. Q. No. **1** is compulsory. **All** questions carry equal marks.

Attempt any **five** questions

1. Attempt any five parts (all parts carry equal marks) : (5×3=15)

   (a) Represent $(-56)_{10}$ in signed magnitude and 1's complement representation limited to 8-bits.

(b) Define deflection sensitivity in Cathode Ray Oscilloscope?

(c) The accumulator of 8085 microprocessor contains AAH and carry is set. What will accumulator and carry contain after the execution of 'XRA A' instruction?

(d) Realize OR gate using diodes and resistors.

(e) Why is D Flip-flop referred to as transparent latch?

(f) Draw the circuit for 4-bit even parity generator.

(g) Subtract 23_{10} from 39_{10} using 2's complement method.

2. (a) Draw the labelled block diagram of a Cathode Ray Tube (CRT)? Explain the role of the following : (8)

(i) Aqua Dag coating

(ii) Control Grid

(b) Minimize the following logic expression using K – map and realize it using NAND gates only $F(A, B,C,D) = \Sigma m(1, 3, 7, 11, 15) + d(0, 2, 5)$

(7)

3. (a) Draw the circuit diagram of Serial Shift Register and hence describe its working in serial in serial out (SISO) and serial in parallel out (SIPO) modes. (8)

(b) Distinguish between a 4-bit multiplexer and an encoder using appropriate diagrams. Using block diagrams realise 8×1 multiplexer using two 4×1 multiplexers and an OR gate and explain its functioning? (7)

4. (a) Write an assembly language program to multiply two 8 bit numbers, one of which is stored in memory location 2050H and other one in memory location 2051H. Store the product in memory locations 2053H and 2054H. (8)

(b) Explain the working of a 2's complement 4-bit adder - subtractor with an appropriate logic circuit diagram. (7)

5. (a) Describe the phenomena of racing in JK flip-flop. Hence explain how this condition can be avoided with the use of master-slave JK flip-flop. (8)

(b) Describe the working of a decade counter (MOD-10) with a suitable diagram? (7)

6. (a) Draw the circuit diagram of 555 timer IC in Astable configuration and hence explain its working in terms of the charging and discharging of its timing capacitor by drawing the relevant wave diagrams. (8)

(b) Write an assembly language programme to divide two hexadecimal numbers. (7)

7. (a) Draw the logic pin out diagram of 8085 microprocessor wherein all the different signals are depicted and classified in different groups. (8)

(b) What are flags? Describe various flags (in detail) for 8085 microprocessor. (7)

[This question paper contains 4 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1015 C

Unique Paper Code : 32221501

Name of the Paper : Quantum Mechanics and Applications

Name of the Course : B.Sc. (Honors) Physics

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. Attempt **FIVE** questions in all. Question No. **1** is compulsory.
3. **All** questions carry equal marks.
4. Non programmable calculators are allowed.

1. Attempt any **FIVE** of the following :

(a) Calculate the commutator $[\widehat{L_x}, \widehat{p_x}]$. (given $[\hat{x}, \widehat{p_x}] = i\hbar$).

(b) The wave-function of a particle is $\psi(x) = \sqrt{\frac{2}{L}} \sin\frac{n\pi x}{L}$ for $0 \le x \le L$. Determine the probability of finding the particle at x = L/3 for n = 3 state.

P.T.O.

(c) Derive the relation between 'magnetic dipole moment' and 'orbital angular momentum' of an electron revolving around a nucleus.

(d) Write the quantum numbers for the state represented by $4^2F_{5/2}$.

(e) Normalize the wave function e^{-ax^2} in a one-dimensional space.

(f) A free particle of mass m is described by the wave-function $\psi(x) = A\exp(i\mu x)$ where A and μ are constants. Determine the probability current density for this particle.

(g) Determine the uncertainty in position for the normalized wave-function $\psi(x) = \left(\frac{2\alpha}{\pi}\right)^{1/4} e^{-\alpha x^2}$ for $-\infty < x < \infty$. (5×3=15)

2. (a) Explain the concept of expectation values. Give expressions for the expectation values of velocity, momentum and energy in terms of respective operators in three dimensions. Mention the difference between expectation values and eigenvalues of an operator corresponding to a dynamical variable.

(b) The wave-function of a particle of mass m is given by

$$\Psi(x) = \left(\frac{\beta^2}{\pi}\right)^{1/4} e^{-\beta^2 x^2/2} \text{ for } -\infty < x < \infty.$$

Determine the total energy of the particle, if potential energy is $V(x) = \frac{1}{2}m\omega^2x^2$. (7,8)

3. The Gaussian wave packet for a free particle is defined by the wave function

$$\Psi(x,0) = N\,exp\left(-\frac{x^2}{2\sigma^2} + ik_0x\right).$$

Prove that the centre of this Gaussian wave packet travels with a velocity $v = \frac{k_0\hbar}{m}$.

(Use $\int_{-\infty}^{\infty} e^{-x^2/\sigma^2}\,dx = \sigma\sqrt{\pi}$ and $\int_{-\infty}^{\infty} e^{-(ax^2 \pm bx)}\,dx = \sqrt{\frac{\pi}{a}}e^{b^2/4a}$).

(15)

4. (a) Solve the Schrodinger equation for a linear Harmonic Oscillator and obtain first two eigenfunctions. (10)

(b) Find ΔX and ΔP for the ground state eigenfunction of linear Harmonic Oscillator and obtain the uncertainty principle. (5)

5. (a) The 'θ' equation obtained after applying separation for variables to the Schrodinger equation for a 3D hydrogen atom in spherical polar coordinates, is given by

$$\frac{1}{sin\theta}\frac{d}{d\theta}\left(sin\theta\frac{d\Theta}{d\theta}\right) + \left(\lambda - \frac{m_l^2}{sin^2\theta}\right)\Theta = 0.$$

Solve the above equation for $m_l = 0$ (or otherwise) to show that

$$\lambda = l(l+1), \quad l = 0,1,2, \ldots\ldots\ldots$$ (12)

P.T.O.

(b) An electron in a hydrogen atom is in a state described by

$$\psi = \frac{1}{\sqrt{6}}[2\psi_{100} + \psi_{211} + \psi_{21-1}]$$

Calculate the expectation value of $\hat{L}_z$ in this state.

(Given $\int_0^\infty x^n e^{-ax} dx = \frac{n!}{a^{n+1}}$ and

$$\psi_{100} = \frac{1}{\sqrt{\pi}}\left(\frac{1}{a_0}\right)^{\frac{3}{2}} e^{-r/a_0}$$

$$\psi_{211} = \frac{1}{8\sqrt{\pi}a_0^{3/2}}\frac{r}{a_0}e^{-r/2a_0}\sin\theta\, e^{+i\phi}\ )$$

(3)

6. (a) What is Larmor Precession? Draw the relevant diagram and derive the expression for Larmor frequency.

(b) A beam of silver atoms moving with a velocity 10^7 cm/s passes through a magnetic field of gradient 0.5 $Wb/m^2/cm$ for 10 cm. What is the separation between the two components of the beam as it comes out of the magnetic field?

(8,7)

7. (a) What is spin orbit coupling? Explain the fine structure splitting in the energy levels due to this. For the 2p level of the hydrogen atom with $E_n = -3.14$ eV, evaluate the fine structure splitting.

(b) Consider a two-electron system with $l_1 = 1$, $l_2 = 1$. Explain the LS coupling scheme in such a case. Write the spectral notation for each state. (10,5)

(2000)

[This question paper contains 4 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1051 **C**

Unique Paper Code : 32221502

Name of the Paper : Solid State Physics

Name of the Course : **B.Sc. (Hons.) Physics CBCS (Core)**

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. Attempt any **five** questions in all.
3. Question number **1** is compulsory.
4. **All** questions carry equal marks.

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

(a) Prove that for a SC lattice, $d_{100} : d_{110} : d_{111} = \sqrt{6} : \sqrt{3} : \sqrt{2}$; where 'd' represents interplanar distance in a crystal.

P.T.O.

(b) An element has a cubic structure having lattice constant as 4.28 Å, and with two of its atoms in the unit cube at (0,0,0) and (1/2, 1/2, 1/2). Find out the distance between nearest neighbours in this element.

(c) The Debye Temperature for Diamond is 2230 K. Calculate the highest possible vibrational frequency.

(d) The energy near the top of the valence band of a crystal is given by $E= -Ak^2$, where $A = 10^{-39}\ Jm^2$ and k is the wave vector. An electron with wave vector $k = 10^{10}\ \widehat{k_x}\ m^{-1}$ is removed from an orbital in a completely filled valence band. Find the effective mass, momentum and energy of the hole. Given Planck's constant $h = 6.62 \times 10^{-34}$Js.

(e) What are the basic assumptions of Drude's model for describing electron motion in metals.

(f) Distinguish between dia-, para- and ferromagnetism.

(g) Calculate the electronic polarizability of Neon. The radius of Neon atom is 0.158 nm. ($\varepsilon_0 = 8.854 \times 10^{-12}$ F/m).

(h) Calculate the critical current which can flow through a long thin superconducting wire of aluminium of diameter 10^{-3} m. The critical field for aluminium is 7.9×10^3 A/m.

2. (a) What is Geometrical structure factor? Derive its expression for FCC structure having identical atoms. Will reflection from (211) plane be possible for this structure? (10)

(b) Show that reciprocal lattice of a BCC lattice is a FCC structure. (5)

3. (a) Derive the expression for specific heat of a solid based on Einstein's model. Explain why this model was not successful. (8)

(b) Deduce the dispersion relation for a linear monatomic chain of atoms and show that the group and phase velocities of a wave are same in the long wavelength limit. (7)

4. (a) Find the expression for the Hall coefficient of a semiconductor in which both electrons and holes are present in equal concentrations. How will this expression change if the hole concentration is twice the electron concentration and vice-versa? Also, explain how will this expression be modified if the semiconductor is heavily doped with p-type impurity or n-type impurity? (12)

(b) Distinguish between direct and indirect band gap with the help of diagram. (3)

5. (a) Derive the expression for Curie-Weiss law using Weiss theory of Ferromagnetism. (6)

(b) Discuss the concept of hysteresis and show that the B-H hysteresis loop gives the value of energy dissipated per cubic meter of the material per cycle of magnetization. (6)

(c) A magnetic substance has 10^{28} atoms/m^3. The magnetic moment of each atom is 1.8×10^{-23} Am^2. Calculate the paramagnetic susceptibility at 300K. What would be the dipole moment of a bar of this material 0.1 m long and having cross-sectional area of 1 cm^2 in a field of 8×10^4Am, $\mu_0 = 4\pi \times 10^{-7}$ henry/m, $k_B = 1.38 \times 10^{-23}$ J/K. (3)

6. (a) Explain the concept of Local Electric Field in a dielectric and derive its expression for structures possessing cubic symmetry. (8)

(b) Obtain Clausius-Mossotti's relation between polarizability and dielectric constant of a solid. (7)

7. (a) Explain the phenomenon of superconductivity. Derive London's first and second equations and discuss penetration depth in a superconductor with the help of a diagram. (12)

(b) Show that the susceptibility of superconductors is –1 and relative permeability is zero. (3)

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[This question paper contains 6 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1140 **C**

Unique Paper Code : 32227502

Name of the Paper : Advanced Mathematical Physics (DSE – Paper)

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

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. Attempt **five** questions in all taking at least **two** questions from each section.
3. **All** questions carry equal marks.

SECTION A

1. (a) Is the set $\{1, -1, i, -i\}$ a group under multiplication? (5)

P.T.O.

(b) Show that W is not a subspace of vector space V where

$$W = \{f : f(7) = 2 + f(1)\}.$$ [5]

(c) Consider the following subspace of R^4:

$W = \{(a, b, c, d): b + c + d = 0\}$

Find the dimension and basis of W. (5)

2. (a) Determine whether the transformation, $T: R^3 \rightarrow R^3$ defined by,

$T(x, y, z) = (x + 2y - 3z, x + y + z, 7x - y + 5z)$

is linear or not. (5)

(b) Let $T: R^3 \rightarrow R^3$ be defined by

$T(x, y, z) = (x + y - 2z, x + 2y + z, 2x + 2y - 3z)$.

Show that T is a non-singular transformation. (5)

(c) Linear transformation T on R^2 is defined as

$$T(x, y) = (3x - 4y, x + 5y)$$

Find the matrix representation of T relative to the u-basis: $\{u_1 = (1, 3) \text{ and } u_2 = (2, 5)\}$. (5)

3. (a) Assume that A, $I - A$, $I - A^{-1}$ are all non-singular matrices, show that :

$$(I - A)^{-1} + (I - A^{-1})^{-1} = I \qquad (5)$$

(b) Find the condition for the following matrix to be orthogonal

$$\begin{bmatrix} a+b & b-a \\ a-b & a+b \end{bmatrix}. \qquad (5)$$

(c) Evaluate C^{20}, where $C = \begin{bmatrix} -1 & 3 \\ 1 & 1 \end{bmatrix}$. (5)

4. (a) Given a matrix $A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$, prove that its eigenvalue equation is given by

$\lambda^2 - \lambda Tr(A) + det(A) = 0.$ (5)

(b) Solve the following system of differential equations using matrix method

$$\dot{y} = z$$
$$\dot{z} = y$$

where, $y(0) = 4$, $z(0) = 2$. (10)

SECTION B

5. (a) Prove that $\delta_{pr} \in_{prs} = 0$. (3)

(b) If $B_{ps} = \in_{psk} A_k$, show that

$$A_u = \frac{1}{2} \in_{ups} B_{ps}$$ (5)

(c) If a tensor A_{ijklm} is symmetric with respect to two indices i and k in the coordinate system x_i, then show that it is symmetric with respect to the same indices in any other co-ordinate system $\bar{x}_p$. (7)

6. (a) Prove that

$$\in_{abc} \in_{pkm} = \begin{vmatrix} \delta_{ap} & \delta_{ak} & \delta_{am} \\ \delta_{bp} & \delta_{bk} & \delta_{bm} \\ \delta_{cp} & \delta_{ck} & \delta_{cm} \end{vmatrix}$$

and hence show that

$$\in_{ibc} \in_{ikm} = \delta_{bk}\delta_{cm} - \delta_{bm}\delta_{ck}$$ (8)

(b) Using tensor methods, verify the identity

$$\vec{\nabla}(\vec{A}.\vec{B}) = \vec{A} \times (\vec{\nabla} \times \vec{B}) + \vec{B} \times (\vec{\nabla} \times \vec{A}) + (\vec{A}.\vec{\nabla})\vec{B} + (\vec{B}.\vec{\nabla})\vec{A}$$ (7)

7. (a) Stress tensor (p_{ij}) satisfies the equations $p_{ij} \in_{ijk} = 0$ and $p_{ij} = f_i n_j$, where f_k is the restoring force per unit area along x_k - axis and $\hat{n}$ is the arbitrary unit vector. Prove that stress tensor is a symmetric tensor of order two. (5)

(b) Stress tensor and strain tensor are related as

$$p_{ij} = \omega_{ijks} e_{ks},$$

where, elastic tensor ω_{ijks} is symmetric in i, j and k, s and its general form is

$$\omega_{ijks} = \lambda \delta_{ij} \delta_{ks} + \mu \delta_{ik} \delta_{js} + \gamma \delta_{is} \delta_{jk}.$$

Prove that

(i) $\omega_{ijks} = \lambda \delta_{ij} \delta_{ks} + \mu(\delta_{ik} \delta_{js} + \delta_{is} \delta_{jk})$

(ii) $p_{ii} = (3\lambda + 2\mu) e_{ii}$ (7)

(c) Let the state of stress at a point in a solid body is given by

$$S_{ik} = \begin{bmatrix} 10 & 10 & 20 \\ 10 & 20 & 0 \\ 20 & 0 & 55 \end{bmatrix}$$

P.T.O.

Find the normal stress and shear stress on the surface defined by

$$3x - 2y + 2z = 10 \quad (3)$$

8. (a) Prove that g_{ij} is a covariant tensor of rank 2. (5)

(b) If $ds^2 = 3(dx^1)^2 + 5(dx^2)^2 + 4(dx^3)^2 - 6dx^1dx^2 + 4\,dx^2dx^3$

Find the matrices

(i) g_{ij} (4)

(ii) g^{ij} (4)

(iii) the product of (g_{ij}) and (g^{ij}) (2)

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[This question paper contains 4 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1240 **C**

Unique Paper Code : 32227504

Name of the Paper : Nuclear and Particle Physics

Name of the Course : **B.Sc. (Hons.) Physics-CBCS**

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. Attempt **five** questions in all. Question No. **1** is compulsory.
3. **All** questions carry equal marks.
4. Use of Scientific Calculator is allowed.
5. Values of required constants have been given at the end.

1. Answer any **five** : (3×5=15)

   (a) Determine the radius of ^{208}Pb.

   (b) What are magic numbers? What is their significance?

   (c) Give three main differences between direct and compound-nucleus reactions.

P.T.O.

(d) What is stripping reaction? Give one example of stripping reaction.

(e) Differentiate between pair production and internal pair conversion.

(f) Why is G.M. counter not suitable for energy and charge spectroscopy applications?

(g) What would be the energy that is required to annihilate proton and antiproton?

(h) Why photoelectric effect is not possible with free electrons?

2. (a) Plot the binding energy per nucleon vs mass number. Explain with its help the release of energy in the processes of fission and fusion.

(b) Calculate de Broglie wavelength for an electron having energy 15 MeV. Show that electron does not exist inside the nucleus.

(c) Find the energy required to knock out nucleons from the He nucleus. (7+3+5)

3. (a) Explain liquid drop model. Obtain semi-empirical mass formula. Give any two achievements of the model.

(b) Calculate the coulomb energy of $^{238}_{92}U$.

(c) State the assumptions of Fermi gas model of nucleus. (8+5+2)

4. (a) What conservation laws were apparently violated due to typical continuous energy distribution of the β-decay electrons? How did Pauli proposal of new particle overcome on these violations?

(b) The total energy liberated in the α-decay of $^{226}_{88}Ra$ is 4.87 MeV, (i) Identify the daughter nucleus, (ii) calculate the kinetic energy of α-particle and (iii) calculate the recoil energy of the nucleus.

(c) Explain secular and transient equilibrium.

(7+4+4)

5. (a) How does a heavy charged particle interact with matter? Derive an expression for the energy loss per unit path length travelled by the heavy charged particle.

(b) Define the Q-value for a nuclear reaction. What is its significance. If the Q-value for the reaction $^{14}Na(\alpha,p)^{17}O$ is –1.20 MeV, find the minimum kinetic energy in the lab system required by an α particle to cause this reaction. (10+5)

6. (a) Explain the procedure by which high potential of the order of MV is generated in a Tandem accelerator. Explain the purpose of using SF_6 gas in Tandem accelerator tank.

(b) Define quenching in GM counters. A GM counter consists of a 50 mm diameter grounded tube with a wire of 25 pm diameter at +700 V in the centre. What is the electric field at the wire?

(c) A cyclotron with Dee's of diameter 1.8 m has a magnetic field of 0.8 T. Calculate the energy to which the doubly ionised helium ion He^{++} can be accelerated. Also calculate the number of revolutions the particle makes in attaining this energy. [Mass of $He^{++} = 6.68 \times 10^{-27}$kg]

(5+5+5)

7. (a) Give the quark structure of a neutron and based upon quark structure give the correct charge number, spin, baryon number and strangeness.

(b) Check whether strangeness and baryon number of the following decay is conserved or not?

(i) $p + p \rightarrow p + \Lambda^0 + \Sigma^+$

(ii) $\pi^- + p \rightarrow \Sigma^\circ + \nu$

(c) What are strange particles? Find the charge number, baryon number and strangeness of a particle described by the quark structure (sss). Identify the particle. (6+4+5)

PHYSICAL CONSTANTS

$m_H = 1.007825$ u,	$m_n = 1.008665$ u
$m_e = 0.00055$ u,	$m(^4_2He) = 4.002603$ u
$1\ u = 1.66 \times 10^{-27}$ kg,	$R_0 = 1.2$ fin
$e_0 = 8.85 \times 10^{-12} C^2/Nm^2$,	$h = 6.6 \times 10^{-34}$ Js
$c = 3 \times 10^8$ m/s,	$1\ eV = 1.6 \times 10^{-19}$J

(1500)

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[This question paper contains 4 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1010 **D**

Unique Paper Code : 2222511101

Name of the Paper : Mechanics

Name of the Course : **B.Sc. (Prog.)**

Semester : I

Duration : 2 Hours Maximum Marks : 60

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **four** questions in all.
3. **All** questions carry equal marks.
4. Question No. **1** is compulsory.
5. Non-programmable calculator is allowed.

1. Attempt all :

(5×3)

(a) Prove that $\vec{A} = 3y^4 Z^2 \hat{i} + 4x^3 Z^2 \hat{j} - 3x^2 y^2 \hat{k}$ is solenoidal.

(b) Write short note on inertial and non-inertial frame of reference.

(c) A particle of mass m moves along the curve $\vec{r} = 2t^2 \hat{i} + (t^2 - 4t)\hat{j} - (t + 5)\hat{k}$, find its angular momentum.

(d) State and prove work-energy theorem.

(e) Calculate the period of revolution of Neptune around the sun, given that the diameter of the orbit is 30 times the diameter of the earth's orbit around the sun. Assume both orbits are circular.

2. (a) Evaluate $\vec{\nabla} \times \left(\frac{\vec{r}}{r^2}\right)$, where $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$. (7)

(b) Solve the differential equation :

$y'' + 2y' + y = 0;\ y(0) = 1,\ y'(0) = -1$ (5)

(c) Find the speed at which the mass of an electron is double of its rest mass. (3)

3. (a) Deduce an expression for the moment of inertia of a rectangular lamina of length I and width b about an axis through its centre and parallel to one side. Hence also find the moment of inertia about an axis coinciding with one side. (7)

(b) What are central forces? Give examples and show that under the influence of a central force field the angular momentum is conserved. (5)

(c) Explain elastic and inelastic collision. (3)

4. (a) What is the simple pendulum. Derive the differential equation for simple pendulum having mass m and length l. What are the drawbacks of simple pendulum. (7)

(b) If we double the length of the pendulum, what effect will you see on the time period of simple pendulum? Does mass affect the time period also? (5)

(c) If $\vec{F} = (2xy + z^3)\hat{i} + x^2\hat{j} + 3xz^2\hat{k}$, determine whether is it conservative or non-conservative force. (3)

5. (a) State and deduce the mathematical expression for the law of relativistic velocities. Show that the resultant velocity of a particle can never be greater than c. (7)

(b) A person in a train at a speed 3×10^7 m/s sleeps at 10:00 pm by his watch and gets up at 4:00 am. How long did he sleep according to the clock at the station? (5)

(c) Four particles each of mass m are kept at the four corners of a square of side 'a'. Find the moment of inertia of the system about a line perpendicular to the plane of the square and passing through the center of square. (3)

[Symbols :
C: speed of light.]

[This question paper contains 4 printed pages.]

Your Roll No..............

Sr. No. of Question Paper : 1708 **C**

Unique Paper Code : 42224303

Name of the Paper : Thermal Physics and Statistical Mechanics

Name of the Course : **B.Sc. Prog. – CBCS_Core**

Semester : III

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** is compulsory.
3. Attempt any **five** questions in all.
4. Use of non-programmable scientific calculator is allowed.

1. Attempt any **five** of the following : (5×3)

(a) Define the concept of temperature and the law that defines it.

P.T.O.

(b) Calculate average energy of Planck's oscillator vibrating with frequency 1.5×10^{14} Hz at temperature 1800K.

(c) Find expression for work gone during adiabatic process.

(d) Find the atomicity of a monoatomic gas using law of equipartition of energy.

(e) Draw T-S diagram of Carnot cycle. What is its advantage?

(f) Define thermodynamic probability of a thermal system.

(g) The radius of argon atoms is 0.128nm. Calculate their mean free path at 25°C and one atmospheric pressure. Given $k_B = 1.38 \times 10^{-23} JK^{-1}$.

2. (a) Describe the porous plug experiment and obtain the expression for Joule Thompson change in temperature. Why do hydrogen and Helium exhibit rise in temperature during the throttling process?

(b) Calculate the change in temperature when helium is made to undergo Joule-Thomson expansion at −173°C and the pressure difference across the plug is 20 atm. Given $R = 8.3 JK^{-1}mol^{-1}$, $a = 3.41 \times 10^{-3} Nm^4 mol^{-2}$, $b = 23.7 \times 10^{-6} m^3 mol^{-1}$ and $C_p = 2.5R$. Take 1 atm = $10^5 Nm^{-2}$. (10,5)

3. (a) State the second law of thermodynamics and explain its physical significance. Prove that the Kelvin Planck and Clausius statements are equivalent.

(b) State and prove Carnot theorem.

(c) Explain the concept of Thermodynamic scale of temperature (6,6,3)

4. (a) Derive the Claussius Clayperon equation for change of state. Discuss effect of pressure on boiling point and melting point.

(b) What are TdS equations? Derive the two TdS equations. (6,9)

5. (a) Define thermodynamic potentials and explain their physical significance.

(b) Using appropriate Maxwell's thermodynamic relations, prove

Cp--Cv = T(dp/dT)v(dV/dT)p (9,6)

6. (a) What are transport phenomena? Deduce expression for coefficient of thermal conductivity K and coefficient of viscosity η of gas on basis of kinetic theory.

   (b) Establish relation between K and η. (10,5)

7. (a) Give the salient features of Blackbody radiation. What was Planck hypothesis to explain the blackbody radiation?

   (b) Derive an expression for mean energy of a resonator using the Planck's hypothesis. (6,9)

8. (a) Distinguish between classical and quantum statistics.

   (b) Derive Fermi-Dirac distribution law for a system of ideal gas containing n molecules.

   (c) Show that Fermions have tendency to occupy higher energy states than bosons. (3,9,3)

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[This question paper contains 8 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1654 **C**

Unique Paper Code : 42227929

Name of the Paper : Elements of Modern Physics

Name of the Course : **B.Sc. Prog. – CBCS_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. Attempt any **five** questions in all.
3. Question No. **1** is compulsory.

1. Attempt any **five** questions. (3×5)

(a) A source of light of wavelength 300 nm with an intensity of 1.0 W/m^2 is incident normally on a potassium surface of area 1.0 cm^2. Determine the number of photoelectrons emitted per second provided 0.4 % of the incident photons produces photoelectrons.

(b) Enlist two shortcomings of Rutherford's atomic model.

(c) An electron is confined to a box of length 10^{-8} m. Calculate the minimum uncertainty in its velocity.

(d) What are stationary states?

(e) A particle of mass m confined to move in a potential $V(x) = 0$ for $0 \leq x \leq a$ and $V(x) = \infty$ otherwise. The wave function of the particle at time $t = 0$ is

$$\psi(x,0) = A\left(2\sin\frac{\pi x}{a} + \sin\frac{3\pi x}{a}\right)$$

Determine A.

(f) Show that nuclear density is a constant, independent of the number of nucleons in the nucleus.

(g) A certain radioactive material has a half-life of 50 days. What is the decay constant and mean life of this element?

2. (a) When an X-ray photon is scattered by an electron (assumed to be initially at rest in the laboratory coordinate system), show that the changed in the wavelength of the scattered photon is given by

$$\lambda' - \lambda = \frac{h}{m_0 c}(1 - \cos\varphi)$$

where m_0 is the rest mass of the electron and φ is the angle through which the photon is scattered. (10)

(b) A moving electron has a de-Broglie wavelength equal to its Compton wavelength. Find its speed. (5)

3. (a) Explain the consistency of Bohr's quantization rule with de-Broglie's hypothesis. (5)

(b) The ionization energy of a hydrogen like Bohr atom is 8.0 rydberg.

(i) Determine the wavelength of the radiation emitted when the electron jumps from the first excited state to the ground state.

(ii) Calculate the radius of the first orbit for this atom. (5,5)

4. (a) State Heisenberg's uncertainty principle for position and momentum measurement. Explain how the gamma ray thought experiment validates this principle. (5)

(b) The speed of an electron is measured to be 5.3×10^3 ms^{-1} to an accuracy of 0.005%. Find the minimum uncertainty in determining the position of this electron. (5)

(c) Using the Heisenberg uncertainty relation in the form $pr = \hbar$, derive an expression for the minimum radius r_1 and energy E_1 of a hydrogen atom. (5)

5. (a) The wave function for a particle moving along the positive x-direction is given by

$$\psi(x,t) = Ae^{i(kx-\omega t)}$$

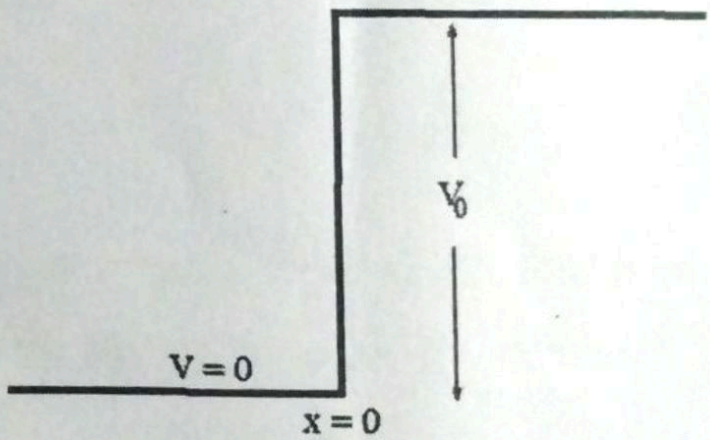
Using this obtain an expression for the momentum and kinetic energy operator in one dimension. (5)

(b) Discuss the probability interpretation of a wave function. Show that the probability density p and probability current density $\overline{J}$ satisfies the continuity equation (10)

$$\frac{\partial \rho}{\partial t} + \bar{\nabla}.\bar{J} = 0$$

6. (a) Consider a one-dimensional rectangular potential of height V_0 defined by

$$V(x) = 0 \quad \text{for } x < 0$$
$$= V_0 \quad \text{for } x > 0$$



A stream particles of mass m having energy $E < V_0$, moves from left to right. Obtain the expressions for the reflection and transmission coefficients of the particle. (7)

(b) Determine the normalized wavefunction of a particle trapped inside a one dimensional infinitely rigid box of 0.1 nm wide and hence deduce the expectation value <x> of the position of a particle. (8)

7. (a) Write the semi-empirical binding-energy formula for a nucleus of mass number A, containing Z-protons and N-neutrons and explain each term appeared in the expression. (5)

(b) (i) Find the energy needed to remove a neutron from the nucleus of the Cobalt isotope $^{59}_{27}Co$. (4)

(ii) Find the energy required to remove a proton from this nucleus. Why these energies are different? (4,2)

8. (a) Complete the following reactions

(i) $^{14}_{6}C \rightarrow {}^{14}_{7}N + \cdots + \cdots$

(ii) ${}^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + \cdots$

(iii) ${}^{22}_{11}Na \rightarrow {}^{22}_{10}Ne + \cdots + \cdots$ (5)

(b) What do you mean by activity of a sample? Give its units and write their relation. Determine the activity of 1.0 g of ^{90}Sr whose half-life against β – decay is 25 years. (3,3,4)

Given : mass of ${}^{12}_{6}C$ = 12.000000 u, mass of ${}^{4}_{2}He$ = 4.002603 u,
mass of ${}^{59}_{27}Co$ = 58.933198 u,
mass of ${}^{1}_{1}H$ = 1.007825 u, mass of ${}^{2}_{1}H$ = 2.014102 u,
m_p = 1.007276 u, m_n = 1.008665 u, m_e = 0.000548 u,
1 u = 1.66054 x 10^{-27} kg, h = 6.62 × 10^{-34}Js,

ϵ_0=8.85 × 10^{-12} F/m