[This question paper contains 4 printed pages.]

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

Sr. No. of Question Paper : 1555 **G**

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) By calculating the Wronskian of the functions x, x^2 and x^3 check whether the functions are linearly dependent or independent.

   (b) Find the coordinates P(1,2) with reference to the new axes, when the axes are rotated by 30° in anticlockwise direction.

P.T.O.

(c) Find the unit tangent vector to any point on the curve

$x = (t^2+1),\ y = (4t-3),\ z = (2t^2-6t)\quad t>0$

(d) Show that if $\Phi(x, y, z)$ is any solution of Laplace equation $\nabla^2 \Phi = 0$, then $\vec{\nabla}\Phi$ is a vector which is both solenoidal and irrotational.

(e) Show that $\oiint (\vec{\nabla} r^2) . \vec{dS} = 6V$ where V is the volume enclosed by surface S.

(f) The probability distribution function is defined by

X:	0	1	2	3	4	5	6
P(X):	k	3k	5k	7k	9k	11k	13k

Find $P(3 < X \leq 6)$. (3×6)

2. (a) Solve by Method of Variation of Parameters:

$d^2y / dx^2 - y = 2 / (1 + e^x)$ (6)

(b) Consider an LCR circuit, governed by the differential equation

$$d^2I/dt^2 + \frac{R}{L}\, dI/dt + \frac{1}{LC} I = \frac{1}{L}\, dE(t)/dt$$

It is connected in series and has R = 10 ohms, $C = 10^{-2}$ farad, L = 1/2 henry and an applied voltage E = 12 V. Assuming no initial current

and no initial charge at t = 0 when the voltage is first applied, find the subsequent current for the problem. (6)

(c) Solve the differential equation :

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

3. (i) Solve by Method of Undetermined Coefficients:

$d^2y/dx^2 + 10\, dy/dx + 25y = 14\, e^{-5x}$ (6)

(ii) Show that following equation is inexact equation and solve it :

$(y^4 + 2y)dx + (xy^3 + 2y^4 - 4x)dy = 0$ (6)

(iii) Solve the following differential equation:

$dy/dx + y/x = y^2$ (6)

4. (i) Show that

$\vec{\nabla} f(r) = f'(r)\, \vec{r} / r$ where $f'(r) = df(r)/dr$

where $\vec{r} = x\hat{\imath} + y\hat{\jmath} + z\hat{k}$. (6)

(ii) Show that

$\vec{F} = (y^2 \cos x + z^3)\hat{\imath} + (2y \sin x - 4)\hat{\jmath} + (3xz^2 + 2)\hat{k}$ is a conservative force field and then evaluate $\oint \vec{F}.\vec{dr}$ over any contour C from (0, 1, −1) to (π/2, −1, 2). (6)

(iii) Prove

$$\vec{\nabla} \times (\vec{\nabla} \times \vec{A}) = -\nabla^2 \vec{A} + \vec{\nabla}(\vec{\nabla} \cdot \vec{A})$$ (6)

5. (i) Verify Divergence Theorem for

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

taken over the cube $0 \le x, y, z \le 1$. (9)

(ii) Verify Green' theorem in the plane for

$$\oint (3x^2 - 8y^2)\,dx + (4y - 6xy)\,dy$$

over C which is boundary of the region defined by $y = \sqrt{x}$, $y = x^2$. (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 Poisson distribution. (8)

(iii) Evaluate $\iiint (2x + y)\,dV$ where V is the closed region bounded by the cylinder $z = 4 - x^2$ and the planes $x = 0$, $y = 0$, $y = 2$ and $z = 0$. (6)

Dec-2023

[This question paper contains 8 printed pages.]

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

Sr. No. of Question Paper : 4370 **G**

Unique Paper Code : 32221101

Name of the Paper : Mathematical Physics – I

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

Semester : I

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. **All** questions carry equal marks.
4. Question No. **1** is compulsory.
5. Non-programmable calculator is allowed.

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

(a) Determine whether the following three vectors are co-planar :

$$\vec{A} = \hat{i} + 3\hat{j} - 2\hat{k}$$

$$\vec{B} = -3\hat{i} + 4\hat{j} + \hat{k}$$

$$\vec{C} = -9\hat{i} + 25\hat{j} - 2\hat{k}$$

(b) For any vector $\vec{A}$ show that

$\vec{A} \cdot \frac{d\vec{A}}{dt} = A\frac{dA}{dt}$ where A is the magnitude of vector $\vec{A}$.

(c) If position vector is $\vec{r} = x\,\hat{i} + y\,\hat{j} + z\,\hat{k}$, then find the value of $\vec{\nabla}(\ln r)$.

(d) If U and V are differentiable scalar functions, prove that $\vec{\nabla}U \times \vec{\nabla}V$ is solenoidal.

(e) Find the angle between surfaces $x^2 + y^2 + z^2 = 9$ and $z = x^2 + y^2 - 3$ at $(2, -1, 2)$.

(f) Evaluate $\int_c \vec{F} \cdot \overrightarrow{dr}$.

where $\vec{F} = \frac{y\hat{i} - x\hat{j}}{x^2 + y^2}$

and c is the circle $x^2 + y^2 = 1$ traversed counterclockwise,

(g) $\frac{dy}{dx} = \frac{y}{x} + x\sin\frac{y}{x}$

Is the given equation homogeneous? Solve this equation.

2. (a) Show that

$$\text{div}(\text{grad}\, r^n) = n(n+1)\, r^{n-2}$$ (5)

(b) Express $A = z\hat{i} - 2x\hat{j} + y\hat{k}$ in cylindrical coordinates. (6)

(c) Show that the force $\vec{F} = r^2\,\hat{r}$ is conservative. Find its scalar potential φ. (4)

3. (a) Verify Green's theorem in the plane for

$$\oint_c (3x^2 - 8y^2)dx + (4y - 6xy)dy$$

where C is the boundary of the region defined by $y = \sqrt{x}$, and $y = x^2$. (9)

(b) If $\vec{A} = (3x^2 + 6y)\hat{i} - 14yz\,\hat{j} + 20xz^2\hat{k}$, evaluate the line integral

$$\int_c \vec{A}.\overrightarrow{dr}$$

from (0, 0, 0) to (1, 1, 1) along the curve C. Given: $x = t,\ y = t^2,\ z = t^3$. (6)

4. (a) Apply the divergence theorem to compute $\iint_s \vec{u}.\hat{n}\, ds$, where S is the surface of the cylinder $x^2 + y^2 = a^2$ bounded by the planes $z = 0,\ z = b$ and where

$$u = x\hat{i} - y\hat{j} + z\hat{k}.$$ (8)

(b) State Stoke's theorem, evaluate

$$\int_C [(x + 2y)dx + (x - z)dy + (y - z)dz]$$

where C is the boundary of the triangle with vertices (2, 0, 0), (0, 3, 0) and (0, 0, 6) oriented in the anti-clockwise direction. (7)

5. (a) What is a probability density function?

$$\text{Given } f(x) = \begin{cases} 0, & x < 2 \\ \frac{1}{18}(2x+3), & 2 \le x \le 4 \\ 0, & x > 4 \end{cases}$$

Show that it is a probability density function. (5)

(b) What is the recurrence relation for Poisson distribution? If the variance of the Poisson distribution is 2, find the probabilities for r = 1, 2, 3, 4. Also find $P(r \ge 4)$. (5)

(c) Derive Normal distribution as limiting case of binomial distribution where $p \neq q$ but $p \approx q$. (5)

6. (a) Solve the differential equation :

$$D^2 + 2D + 1 = x \sin x \quad (8)$$

(b) Show that following equation is Exact and then solve it

$$[(x+1)e^x - e^y]\, dx = xe^y dy \quad (7)$$

7. (a) Using method of Undetermined coefficients, solve the differential equation

$$y'' + 4y = 8x^2 \quad (8)$$

(b) Solve the differential equation :

$$(1+x^2)\,(dy/dx) + 2xy = 4x^2 \qquad (7)$$

[This question paper contains 4 printed pages.]

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

Sr. No. of Question Paper : 4811 **G**

Unique Paper Code : 42221101

Name of the Paper : Mechanics

Name of the Course : **B.Sc. Physical Sciences_Core_CBCS**

Semester : I

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.
4. Attempt **four** questions from the rest of the paper.

1. Attempt all :

   (a) What is 'Newtonian principle of relativity'? Illustrate with an example.

   (b) Show $\nabla \times \vec{F} = 0$, if $\vec{F}$ is a conservative force.

P.T.O.

(c) Show that when a particle is under the action of a central force, torque is zero.

(d) What is a compound pendulum? How does it differ from a simple pendulum.

(e) Explain why an electron cannot be accelerated to a velocity greater than the velocity of light in free space. (5×3=15)

2. (a) Explain briefly the physical significance of gradient, divergence and curl.

(b) Find $\nabla\varphi$ if $\varphi = \ln|\mathbf{r}|$, where $\mathbf{r} = x\hat{i} + y\hat{j} + z\hat{k}$.

(c) Solve

$$\frac{d^2y}{dx^2} + 4\frac{dy}{dx} + 5y = 0, \quad y=2 \text{ and } \frac{dy}{dx} = \frac{d^2y}{dx^2} \text{ when } x=0$$

(3+4+8=15)

3. (a) Show that a conservative force can be expressed as $\vec{F} = -\,grad\,U$, where U is the potential energy.

(b) Suppose three masses of 2 kg, 3 kg and 4 kg are moving with velocities $\vec{v_1} = \hat{i} + 2\hat{j} + 3\hat{k}$, $\vec{v_2} = -\hat{i} - 3\hat{j} + \hat{k}$ and $\vec{v_1} = 3\hat{i} - 2\hat{j} + 2\hat{k}$, respectively, in a laboratory system of reference. Caluclate the velocity of the centre of mass of the system.

(c) What is collision? Show that in perfectly inelastic collision in the laboratory system there is always a loss of kinetic energy. (5+4+6=15)

4. (a) Illustrate with examples the principle of conservation of angular momentum.

(b) Deduce an expression for the moment of inertia of a rectangular bar about an axis perpendicular to the length of the bar and passing through one of its sides.

(c) A solid sphere rolls down an inclined plane with an acceleration of 3.5 m/s^2. Calculate the inclination of the plane. Also calculate the acceleration of a hollow sphere rolling down the same inclined plane. (3+7+5=15)

5. (a) (i) What is the meaning of a geostationary satellite and explain why is it a special case of geosynchronous satellite'.

(ii) Describe motion of a satellite around the earth in a circular orbit.

(b) Obtain differential equation of motion of a damped harmonic oscillator.

(c) A body of mass 2 kg attached to a spring executes simple harmonic motion with a time period 2.4 sec. When the mass of the body is increased to 8 kg and set to make simple harmonic motion, calculate the time period of oscillations.

(7+4+4=15)

6. (a) Write a short note on Lorentz transformations for coordinates.

(b) What was the purpose of Michelson-Morley experiment? How did Einstein explain the negative results of this experiment.

(c) What do you understand by length contraction and time dilation? The mean life of π meson is 2×10^{-8} sec. Calculate the mean life of a π meson moving with a velocity of 0.8 c. (3+5+7=15)

7. (a) Find expressions for the energy and momentum of a particle measured in a moving reference frame on the basis of Lorentz transformation.

(b) Electrons from a two million-volt electron gun emerge with speeds which are about 98 percent of the speed of light in free space. Prove that to a stationary observer in the laboratory, these electrons appear to have a mass which is five times their rest mass. (10+5=15)

[This question paper contains 8 printed pages.]

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

Sr. No. of Question Paper : 1593 **G**

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. **All** Questions carry equal marks.
3. Q. No. **1** is compulsory.
4. Answer **any four** of the remaining five questions.
5. Use of non-programmable scientific calculators are allowed.

1. Attempt all parts of this question.

   (i) A block of mass 2 kg is placed on a frictionless platform and the coefficient of static friction between theblock and the platform is 0.6. The platform is subjected to an acceleration a. Determine the maximum acceleration of the platform such that the block does not slip on it. (3)

(ii) Find the work done in moving a particle from the point A(–2, 1, 3) to B(1, –2, –1) in the force field

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

(3)

(iii) A cosmic ray proton with energy 10^{20} eV crosses our galaxy, which has diameter of about 10^5 light years. How long does it take the proton to traverse the galaxy, in its own rest frame? Use the following : 1 eV = 1.6×10^{-19} J, mass of proton is about $m_p = 1.67 \times 10^{-27}$ kg. (3)

(iv) The centre of mass of three particles of masses 10 gm, 20 gm and 30 gm is at (1, –2, 3). Where should the fourth particle of mass 40 gm be placed so that the centre of mass of the combined system is at (1,1,1)? (3)

(v) A particle of mass m moves in a central force field defined by $\vec{F} = -\frac{k}{r^4}\hat{r}$. If E is the total energy of the particle then find the speed of the particle. (3)

(vi) A particle of mass 10 kg is moving in a circle of radius 4 m with a constant speed of 5 ms^{-1}. What is its angular momentum about a point on the axis passing through the centre of the circle and perpendicular to its plane, at a distance of 3 m from its centre? (3)

2. (i) Explain the principle of rocket propulsion. Formulate the equation of motion of a rocket and hence deduce an expression for the instantaneous velocity of the rocket that takes off vertically upwards from rest under the influence of gravity. (6)

(ii) A rocket launched vertically expels mass at a constant rate equal to 0.05 m_0 kg ms^{-1}, where m_0 is its initial mass. The exhaust velocity of the gases relative to the rocket is 5 km s^{-1}. Find the velocity & the height of the rocket after 10 s. (6)

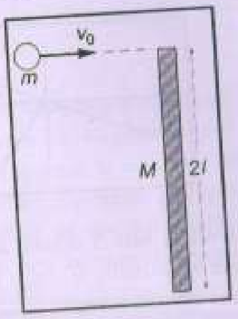
(iii) Determine the centre of mass of a circular plate of uniform thickness t and diameter 2R. If a circular hole of diameter R is drilled into the plate at its boundary, will the centre of mass of the remaining portion of the plate change? If yes, then determine the centre of mass of the remaining portion of the plate. (6)

3. (i) State and derive an expression for Work-Energy Theorem. (6)

(ii) A commonly used potential energy function to describe the interaction between two atoms is the Lennard-Jones potential defined as

$U(r)=\varepsilon\left[\left(\frac{r_0}{r}\right)^{12}-2\left(\frac{r_0}{r}\right)^{6}\right]$, where r is the separation between the two atoms. Are the two atoms interacting with each other by a central force? Show that the radius at the potential minimum is r_0 and that the depth of the potential is ε. Find the frequency of small oscillations about equilibrium for two identical atoms of mass m bound to each other by the Lennard-Jones interaction. (6)

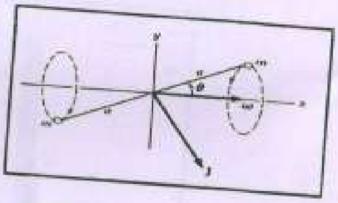
(iii) A plank of length 2*l* and mass M lies on a frictionless table. A ball of mass m and speed v_0 strikes its end as shown in the figure. Find the final velocity of the ball, v_f, assuming that mechanical energy is conserved and that v_f is along the original line of motion.



(6)

4. (i) Derive an expressions for Moment of Inertia of a uniform mass distribution in the form of a spherical shell about one of its tangential axis. (6)

(ii) Consider a rigid body consisting of two equal masses m joined by a massless rod of length 2a. The rod is made to rotate about a fixed axis through the Centre of Mass (CM) and oriented at angle θ with the length of the rod as shown in the figure. Derive an expression for the angular momentum $\vec{J}$ of the rod and hence show that $\vec{J}$ rotates with the rod always inclined at a fixed angle relative to the rod and to the axis of rotation. (6)



(iii) A bowling ball is thrown down the alley with speed v_0. Initially it slides without rolling, but due to friction it begins to roll. What is its speed when it rolls without sliding. (6)

5. (i) Using the radial and tangential equation of motion, show that the angular momentum l and the energy E of a particle of mass m moving in a potential U(r) can be expressed as $l = mr^2\dot{\theta}$ and $E = \frac{1}{2}m\dot{r}^2 + \frac{l^2}{2mr^2} + U(r)$. Hence, obtain the effective force acting on the particle. (6)

(ii) A planet of mass m and angular momentum l moves in a circular orbit in a central potential $U(r) = -kr^{n+1}$, where k is a constant and r is the distance of the particle from the origin. Find the angular frequency of radial oscillations if the particle is slightly perturbed radially. Determine the value of n for which the orbit can be stable. (6)

(iii) A particle of mass 50 g moves under an attractive central force of magnitude $4r^3$ dynes. The angular momentum is equal to 1000 g cm^2s^{-1}. Find the effective potential energy of the particle. If the radius of the particle's orbit varies between r_0 and $2r_0$ then determine r_0. (6)

6. (i) A frame of reference is rotating relative to an inertial frame with a constant angular speed ω. Determine expressions for the Centrifugal and the Coriolis forces acting on a particle of mass m, observed to move in the rotating frame of reference. (6)

(ii) Two particles of rest mass m_0 approach each other with equal and opposite velocity v. What is the total energy of one particle as measured in the rest frame of the other? (6)

(iii) Muons are unstable particles that spontaneously decay into an electron and two neutrinos. If the number of muons at time $t = 0$ is N_0, the number at time t is given by $N = N_0 e^{-t/\tau}$ where $\tau = 2.2\mu s$ is the mean lifetime of a muon in a frame of reference in which the muon is at rest. If a bunch of muons are moving at speed 0.95c, what is the observed mean lifetime? What fraction of muons remain after the bunch has travelled a distance of 10.0 km? (6)

[This question paper contains 4 printed pages.]

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

Sr. No. of Question Paper : 1773 **G**

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) If position vector is $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$, then find the value of $\vec{\nabla}(\ln r)$.

P.T.O.

(b) What are conservative and non-conservative forces?

(c) Define moment of inertia. Why does the moment of inertia of a given body depend on the axis of rotation about which it rotates? Explain.

(d) State the Kepler's law of planetary motion.

(e) What are the basic postulates of special theory of relativity?

2. (a) Explain gradient, divergence and curl. What is the significance of divergence and curl of a vector? (7)

(b) Find the solution of the differential equation :

$y'' - 5y' + 6y = 0$; $y(0) = 1$ and $y'(0) = 2$. (5)

(c) What are central forces? Give two examples. (3)

3. (a) Determine the moment of inertia of a circular disc of mass M and radius R about an axis passing through its centre and perpendicular to its plane. (7)

(b) An empty freight car of mass $m_1 = 10{,}000$ kg rolls at $v_1 = 2$m/sec on a level road and collides with a loaded car of mass $m_2 = 20{,}000$ kg standing at rest. If the cars couple together, find their speed v' after the collision, and also the loss in kinetic energy. (5)

(c) Derive the expression of time dilation in relativistic motion. Why do we not observe the effect of time-dilation in everyday life? (3)

4. (a) Explain the failure of Galilean transformation equations and derive the length contraction expression by using Lorentz transformation equation. (7)

(b) A body of mass 0.5 kg is moving in a circle of radius 0.3 m with constant speed of 0.2 m/s. Find out its angular momentum about (i) the centre of the circle, (ii) a point on the axis of the circle and at a distance of 0.4 m from its centre. (5)

(c) We observe two galaxies A and B moving in opposite directions with speeds 0.5c and 0.4c respectively. What is the velocity of galaxy B as seen from galaxy A. (3)

5. (a) Deduce the differential equation of a damped harmonic oscillator. Obtain a solution and discuss in detail the case of under damping. (7)

(b) Centre of mass is at A (2,2,2) when system consists of particles of masses 2,4 and 5 kg. If the centre of mass shift to B (4,4,4) on removing 5kg, what was its position? (5)

(c) A particle is moving in one-dimensional with x(t)=A cosωt + B sin ωt. Show that motion is simple harmonic. (3)

[Symbols:

C: speed of light.

ω: angular frequency]

[This question paper contains 8 printed pages.]

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

Sr. No. of Question Paper : 1631 **G**

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.

P.T.O.

1. Attempt **all** questions. Each question carries equal marks.

(a) Two particles of masses m_1 and m_2 lying on a smooth horizontal plane are connected by a light spring such that when m_1 is held fixed, m_2 oscillates harmonically in the line of the spring with period T_{12}. Show that if m_2 is held fixed, mi will oscillate harmonically with period of T_{21}, such that $m_2T_{21}^2 = m_1T_{12}^2$.

(b) What is a compound pendulum? A circular ring of diameter d and mass M hangs on a nail fixed to a wall. What is the time period of small oscillation of ring?

(c) Discuss the mechanism of energy exchange in a coupled pendulum.

(d) In a series LCR circuit, L = 0.5 henry, C = 5 μF. What should be the maximum value of the resistance R for the condition the discharge to be oscillatory?

(e) A string length 3a and negligible mass is attached to two fixed ends. The tension in the string is T. A particle of mass m is attached at distance a from one end of the string as shown in the Fig. 1. Find the time period of the transverse oscillations (small oscillations) of the mass m.

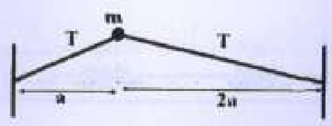


Fig. 1

2. (a) A uniform spring of spring constant k and a finite mass m_s is loaded with a mass M. If m_s is not negligible compared to M show that the period of vertical oscillations of mass spring system is-

$$T = 2\pi\sqrt{\frac{M + \frac{m_s}{3}}{K}}.$$ (10)

(b) Two massless springs of force constant k_1 and k_2 are connected to mass m placed on a horizontal functionless surface as shown in Fig.2(a) and Fig. 2(b). Obtain an expression for the time period of the horizontal oscillations in each case. (5)

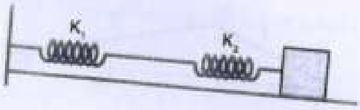


Fig. 2(a)

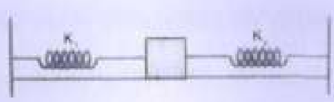


Fig. (b)

3. (a) Two collinear simple harmonic motions, each of amplitude 1.0 cm and frequencies 8 Hz and 6 Hz respectively, act simultaneously on a particle. Assuming that they are in phase, draw the displacement-time curves for the two motions. Also, draw the curve of the resultant displacement over one beat period. What is the beat frequency? (5)

(b) Give the analytical solution of Lissajous figure formed by the superposition of two perpendicular waves having frequency ratio 1:2 and phase difference ϕ. Give graphical representation of Lissajous figure if $\phi = \pi/4$. (6,4)

4. (a) Establish the equation of motion of a damped harmonic oscillator subjected to a damping force that is proportional to first power of its velocity. If the system is under damped, show that motion of the system is oscillatory with its amplitude decaying exponentially with time. (10)

(b) An under damped oscillator has its amplitude reduced to $(1/10)^{th}$ of its initial value after 100 oscillations. If the time period is 2 seconds, calculate (i) the damping constant and (ii) Relaxation time. (5)

5. (a) Two equal masses m are connected with two identical massless springs with spring constant k as shown in Fig. 3. Show that the angular frequencies of two normal modes of vertical oscillation are given by :

$$\omega = \left(3 \pm \sqrt{5}\right)\frac{k}{2m}$$

Also, show that in the slower mode the ratio of the amplitudes is $\frac{1}{2}\left(\sqrt{5}-1\right)$ while in faster mode this ratio is $\frac{1}{2}\left(\sqrt{5}+1\right)$. (10)

Fig. 3

(b) Show that the standing wave $f(x, t) = A\sin(kx)\cos(kvt)$ satisfies the wave equation and express it as the sum of a wave travelling to left and a wave travelling to the right. (5)

(22)

[This question paper contains 4 printed pages.]

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

Sr. No. of Question Paper : 4520 **G**

Unique Paper Code : 32221303

Name of the Paper : Digital Systems and Applications

Name of the Course : **B.Sc. (Hons) 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 **any five** questions in all.
3. **Question No.1** is compulsory.
4. All questions carry **equal** marks.

1. Attempt **any five** parts (all parts carry equal marks): (5x3=15)

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

P.T.O.

(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?

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

(i) AquaDag coating

(ii) Control Grid (8)

(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 x 1 multiplexer using two 4 x 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 : 1769 **G**

Unique Paper Code : 2222512301

Name of the Paper : Heat and Thermodynamics

Name of the Course : **B.Sc. (Prog.) Physical Science– NEP- UGCF**

Semester : III

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. Question no. **1** is compulsory.
3. Attempt any **five** questions including Question no. **1**.
4. **All** questions carry equal marks.
5. Use of non-programmable scientific calculators is allowed.

1. Attempt all parts. Each part carries equal marks.

   (a) Explain the concept of temperature using the zeroth law of thermodynamics.

P.T.O.

(b) Calculate the change in entropy when 1 mole of an ideal gas expands isothermally to three times its original volume.

(c) Calculate the most probable velocity of a Maxwellian gas molecule of mass 5.31×10^{-26} kg at 300K.

(d) Determine the wavelength corresponding to the maximum emissivity of a black body at a temperature T equal to 3 K and 5000 K. In what spectral region will the wavelengths be found? (12)

2. (a) Using the first law of thermodynamics, prove that,

(i) For one mole of an ideal gas, $C_P - C_V = R$

(ii) If E_S and E_T are adiabatic and isothermal elasticity respectively, then

$$E_S/E_T = C_P/C_V = \gamma \quad (4,4)$$

(b) 1 mole of a perfect gas initially at 27°C is compressed adiabatically such that its pressure becomes 10 times its initial value. Calculate,

(i) Its temperature after compression

(ii) Work done during the process

Given : $\gamma = 1.4$ (4)

3. (a) What are Kelvin-Planck statement and Clausius statement of second law of thermodynamics? Show that both the statements are equivalent. Hence derive the mathematical expression of second law of thermodynamics in terms of entropy. (8)

(b) The efficiency of Carnot's engine is 1/5. By decreasing the temperature of the sink by 50K while keeping the source at the same temperature, it increases to 1/3. Find the temperatures of the source and the sink. (4)

4. (a) Define the four thermodynamic potentials? Deduce Maxwell's thermodynamic relations using fundamental equations of thermodynamic potentials. (9)

(b) Prove the following, (symbols have their usual meaning)

$$\left(\frac{\partial H}{\partial P}\right)_T = V - T\left(\frac{\partial V}{\partial T}\right)_P \quad (3)$$

5. (a) Define mean free path λ of the molecules of a gas. If d is the diameter of each molecule and n is the no. of molecules per unit volume, derive expression for λ assuming that all the molecules except the one under consideration are at rest. (8)

(b) Write the expression for the coefficient of viscosity η of an ideal gas in terms of mean free path. How does it vary with absolute temperature of the gas? (4)

6. (a) Describe the spectral distribution of the black body radiation. How does Planck's radiation law lead to Rayleigh's radiation law? (9)

(b) Determine the temperature and the power radiated from 1 cm^2 of stellar surface of the sun with λ_{max} = 5100 Å considering the stellar surface to be a blackbody. (3)

7. (a) What are the salient features of Maxwell Boltzmann statistics? Describe qualitatively how these features are different from Bose-Einstein and Fermi Dirac statistics. (8)

(b) Calculate and show the number of ways of arranging four Bosons in seven different states. (4)

Values of Constants:

Boltzmann's constant, $k = 1.38 \times 10^{-23} JK^{-1}$

Universal gas constant, $R = 8.31 \ Jmol^{-1}K^{-1}$

Wien's constant, $b = 2.898 \times 10^{-3}$ mK

(2000)

[This question paper contains 4 printed pages.]

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

Sr. No. of Question Paper : 1612 **G**

Unique Paper Code : 2222012303

Name of the Paper : Light and Matter

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

Semester : III

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. Answer any **Four** questions in all.
3. Question No. **1** is compulsory.
4. **All** questions carry equal marks.
5. Use of non-programmable calculators is allowed.

1. Attempt all of the following : (5×3=15)

(a) What are coherent sources? What are the methods to obtain coherent sources?

P.T.O.

(b) State and explain Stokes' treatment of phase change on reflection.

(c) Give three advantages of electron microscopy over optical microscopy.

(d) What is the radius of the first half period zone in a zone plate behaving like a convex lens of focal length 50 cm for a light of wavelength 5000 Å?

(e) The threshold frequency for photoelectric emission in a certain metal is 1.4×10^{15} Hz. Find the maximum energy of the photoelectrons when light of frequency 2×10^{15} Hz is incident on the metal surface.

2. (a) What do you understand by wave-particle duality? Explain a fundamental experiment used to explain the wave nature of a particle. (10)

(b) A light beam of wavelength 4000 Å falls on a metallic surface used in an experiment to study the photoelectric effect. If the stopping voltage is 1.5 V, calculate :

(i) the work function of the surface.

(ii) the maximum wavelength of light that will cause photoelectric emission. (5)

3. (a) What are the conditions for obtaining sustained interference? Find the conditions for bright and dark fringes formed due to interference. Graphically show and explain the intensity distribution of the interference pattern. (10)

(b) Newton's rings formed by a monochromatic light between a flat glass plate and a convex lens are viewed normally. Calculate the order of the dark ring which will have double the diameter of that of the 40th dark ring. (5)

4. (a) Explain the theory of Fresnel's half-period zone. Discuss the Fresnel's diffraction at a straight edge with the help of half-period zones. (10)

(b) Monochromatic light of wavelength 7.14×10^{-5} cm falls normally on a grating consisting of parallel wires equidistant from one another. The first-order spectrum is observed at 30° from the zero position. Find the value of the grating constant. (5)

5. (a) What is a plane diffraction grating? Show that the resolving power of a grating is proportional to the number of opaque rulings per metre. (10)

(b) Calculate the number of lines that a grating must have to resolve D1 & D2 lines of sodium in second order, given $\lambda 1 = 5890$ Å and $\lambda 2 = 5896$ Å. (5)

[This question paper contains 4 printed pages.]

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

Sr. No. of Question Paper : 4352 **G**

Unique Paper Code : 32221301

Name of the Paper : Mathematical Physics II

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

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.

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

   (a) Determine if the following functions are odd, even or neither of them:

P.T.O.

(i) $f(x) = \sin x$ if $-\pi < x < \pi$

(ii) $f(x) = x^2$ if $0 < x < 2\pi$

(iii) $f(x) = \begin{cases} 2 - x & \text{if } 0 < x < 4 \\ x - 6 & \text{if } 4 < x < 8 \end{cases}$

(b) Given $f(x + 2\pi) = f(x)$ and $f(x) = |x|$, $-\pi \le x \le \pi$ Plot $f(x)$ in the interval $(-3\pi, 3\pi)$.

(c) Evaluate: $\int_0^\infty x^2 e^{-2x^2} dx$

(d) If $\Gamma(1/2) = \sqrt{\pi}$, find the value of $\Gamma(-1/2)$.

(e) Find the value of $P_n(-1)$

2. (a) Given, $f(x) = \pi - x$, $0 \le x \le \pi$. (7, 3)

Find Fourier sine series and hence show that:

$$\frac{1}{1^2} + \frac{1}{3^2} + \frac{1}{5^2} + \ldots\ldots = \frac{\pi^2}{8}$$

(b) Prove that even function has no sine terms in its Fourier expansion. (5)

3. Find the Fourier series expansion of the function:

$f(x) = x^2$, $-\pi < x < \pi$

Hence, prove that $1 + \frac{1}{9} + \frac{1}{25} + \ldots = \frac{\pi^2}{8}$.

(12, 3)

4. Using Frobenius Method, solve the following differential equation:

$x^2 y'' + 4xy' + (x^2 + 2)y = 0$ (15)

5. (a) 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, find $P_0(x), P_1(x), P_2(x), P_3(x), P_4(x)$. (8)

(b) Prove that:

$$\int_{-1}^{1} P_m(x) P_n(x)\, dx = \frac{2}{2n+1}\delta_{mn} \quad (7)$$

6. (a) Prove that:

$$\int_{0}^{1} x J_n(ax) J_n(bx)\, dx = \frac{1}{2} J_{n+1}^{2}(x)\,\delta_{ab} \quad (12)$$

where $J_n(a) = J_n(b) = 0$

(b) Show that:

$$J_{1/2}(x) = \sqrt{\frac{2}{\pi x}}\sin x \quad (3)$$

7. Determine the solution of one-dimensional wave equation (15)

$$\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}, \qquad 0 \le x \le l, \qquad t > 0$$

under the boundary conditions $u(0, t) = u(l, t) = 0$ and initial conditions

$$u(x, 0) = \begin{cases} x, & 0 \le x \le l/2 \\ l - x, & l/2 < x \le l \end{cases}$$

and $\left.\frac{\partial u}{\partial t}\right|_{t=0} = 0$

[This question paper contains 8 printed pages.]

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

Sr. No. of Question Paper : 1536 **G**

Unique Paper Code : 2222012301

Name of the Paper : Mathematical Physics – III

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

Semester : III

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. Attempt **five** questions in all.
3. **All** questions carry equal marks.
4. Question number **1** is compulsory.
5. Attempt any **two** questions from **Section A**, any **one** question from **Section B** and any **one** question from **Section C**.

P.T.O.

1. Attempt **all** questions : (6×3=18)

(a) Solve $z^3 + 1 = 0$ and plot the roots.

(b) Discuss the analyticity of $|z|^2$ in finite z-plane.

(c) Show that $1 + \cos 72° + \cos 144° + \cos 216° + \cos 288° = 0$.

(d) Find the principal value of $\ln(\sqrt{3} - i)$.

(e) Obtain the Fourier Sine integral representation of $f(x)$, where

$$f(x) = \begin{cases} 4, & 0 < x < 1 \\ 0, & \text{otherwise} \end{cases}$$

(f) A flexible string of length L is stretched between its fixed ends lying at x = 0 and x = L. It is released from rest. Write the initial and boundary conditions for the displacement of the string g(x, t).

Section A

2. (a) Use de Moivre's theorem to prove that :

$$\frac{\sin(4\theta)}{\sin(\theta)} = 2\cos(3\theta) + 2\cos(\theta) \qquad (7)$$

(b) Find all the roots of

$$(1 + z)^5 = (1 - z)^5 \qquad (7)$$

(c) Locate and state the nature of the singularities of the following function in the finite complex plane :

$$f(z) = \frac{(z + 2i)^{1/3}}{z(z^2 + 1)^2} \qquad (4)$$

3. (a) Determine the value of a such that the function $u(x, y) = ax^2 - 3xy$ is harmonic and find its conjugate function v(x, y) such that f(z) = u + i v is analytic. (8)

(b) Evaluate the following integrals where the closed curve C is the positively oriented boun-dary of square whose sides lie along the lines x = ±1 and y = ±1 (5,5)

(i) $\frac{1}{2\pi i}\oint_C \frac{\sin(z)}{(z^2-4)}dz$

(ii) $\oint_C \frac{z\cos(z)}{(2z+1)^2}dz$

4. (a) Use residue theorem to evaluate the integral : (8)

$$\int_0^\infty \frac{x^4}{(x^2+9)(x^2+4)}dx$$

(b) Expand the function $f(z)=\frac{1}{z^2(z+1)}$ in a Laurent series valid for (5,5)

(i) $0 < |z| < 1$

(ii) $|z| > 1$

Section B

5. (a) Find the Fourier Sine transform of e^{-x} and hence evaluate the integral

$$\int_0^\infty \frac{k\sin(kx)}{1+k^2}dk \quad (9)$$

(b) Fourier Sine transform of g(x) is given by the following equation

$$\sqrt{\frac{2}{\pi}}\int_0^\infty g(x)\sin(kx)\,dx = \begin{cases} 0; & k<0 \\ 1-k; & 0\le k\le 1, \\ 0; & k>1 \end{cases}$$

find g(x). (9)

6. (a) If Fourier transform of f(x) is given by

$$\Im[f(x)] = F(k)$$

then show that

$$\Im\{f(bx)\} = \frac{1}{|b|}F\left(\frac{k}{b}\right);\ b \text{ is some constant.} \quad (6)$$

(b) Find the Fourier transform of Dirac-Delta function, $\delta(x)$. (6)

(c) Plot the function and find its Fourier transform

$f(x) = e^{-a|x|},\ a > 0$ (6)

Section C

7. (a) Using method of separation of variables, solve

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

such that $u(0, y) = 8e^{-3y}$ (6)

(b) A rectangular plate (a × b) with insulated surfaces has its temperature u(x, y) as

$$u(0, y) = 0,\ u(a, y) = 0,$$

$$u(x, 0) = 0,\ u(x, b) = F(x)$$

Using 2-D Laplace equation, determine the steady state temperature distribution within the plate. The temperature of the plate has an upper bound $|u(x, y)| < M$. (12)

8. (a) Using method of separation of variables, solve

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

such that $u(x, 0) = 4e^{-3x}$ (6)

(b) A string is stretched between the fixed points (0, 0) and (L, 0) andreleased at rest from the initial deflection given by (a is some constant)

$$y(x,0)=\begin{cases}\dfrac{3ax}{L}, & 0<x<\dfrac{L}{3}\\[2mm] \dfrac{3a}{2L}(L-x), & \dfrac{L}{3}<x<L\end{cases}$$

Using the 1-D wave equation, find the deflection $y(x, t)$ at any time t. (12)

[This question paper contains 4 printed pages.]

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

Sr. No. of Question Paper : 4406 **G**

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. (a) Prove that efficiency of a reversible engine is always higher than efficiency of an irreversible engine working between same limits of temperatures of source and sink.

P.T.O.

(b) A cyclic heat engine does 50 KJ of work per cycle. If efficiency of engine is 75%, what will be the heat rejected per cycle?

(c) Using Maxwells thermodynamic relation, calculate

$\left(\frac{\partial C_V}{\partial V}\right)_T$ for a van der Waals gas.

(d) On the basis of third law of thermodynamics prove the unattainability of absolute zero.

(e) Calculate relative magnitude of average speed, root mean square speed and most probable speed. How do these speeds vary with temperature?

(3×5=15)

2. (a) Using first law show that for a gaseous system, the ratio of adiabatic elasticity to isothermal elasticity is equal to the ratio of two heat capacities.

(b) Calculate work done during adiabatic process.

(c) Apply Zeroth's law of thermodynamics to thermal systems to arrive at the conclusion that at equilibrium the systems are at the same temperature. (7,3,5)

3. (a) What do you understand by thermodynamic scale of temperature? Define absolute zero temperature.

(b) Prove that thermodynamic scale of temperature is equivalent to perfect gas scale.

(c) Prove that if Clausius statement is not true, the same holds for Kelvin-Planck statement.

(7,3,5)

4. (a) Obtain the Clausius inequality and discuss its significance.

(b) Using the TS diagram derive the expression for efficiency of a Carnot cycle.

(c) Calculate the total entropy change when 20 g water at 0°C is mixed with an equal amount of water at. 80°C. (Given : Specific heat of water = 1 cal g^{-1} K^{-1}) (7,3,5)

5. (a) Describe how the process of adiabatic demagnetisation leads to cooling in paramagnetic salt.

(b) From the TdS equations calculate the amount of heat transferred when one mole of van der Waals gas undergoes a reversible isothermal expansion from volume v_i to v_f.

(c) Prove the thermodynamical equations below, using Maxwell relations

(i) $dU = (C_p - pV\alpha_p)dT + V(\beta_T p - \alpha_p T)dp$

(ii) $dH = C_p dT + V(1 - \alpha_p T)dp$

Here α and β denotes coefficient of volume expansion and compressibility, respectively. (7,3,5)

6. (a) What are transport phenomena? Derive an expression for coefficient of viscosity of a gas in terms of mean free path of its molecules.

(b) Discuss the effect of pressure and temperature on coefficient of viscosity.

(c) The mean free path of the molecules of a gas is 2×10^{-7} meters at pressure p and temperature 200 K. Calculate its value at (i) p, 400 K (ii) 2p, 200 K (iii) ½ p, 400K. (7,3,5)

7. (a) Derive and discuss the Van der Waals gas equation of state of a gas. Mention its defects.

(b) Show that for a gas obeying Van der Waals' equation

$$RT_c/P_cV_c = 8/3$$

(c) Calculate Van der Waals' constants for dry air using the following data: T_c = 132 K, P_c = 37.2 atm., and R = 82.07 cm^3 atm K^{-1}. (7,3,5)

[This question paper contains 8 printed pages.]

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

Sr. No. of Question Paper : 1574 **G**

Unique Paper Code : 2222012302

Name of the Paper : Thermal Physics

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

Semester : III

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. Attempt **five** questions in all.
3. **Question No.1** is compulsory.
4. All questions carry **equal** marks.
5. Use of Non-programmable **Scientific calculator** is allowed.

P.T.O.

1. (a) Calculate adiabatic lapse rate if the molecular weight of air is 0.029 Kg mol^{-1} and γ for air is 1.4.

(b) Calculate the critical constants of a gas, given $a=10^{-5}$, the unit of pressure being 1 atm and $b=10^{-3}$, the unit of volume being 1g molecular volume at NTP.

(c) Show diagrammatically how first order phase transition is different from second order phase transition.

(d) 50 g of water at 40° C is converted into ice at -10° C at constant atmospheric pressure. If the specific heat of ice at constant pressure is 0.5 cal $g^{-1}K^{-1}$, calculate the total change in entropy of the system. Latent heat of ice = 80 cal/g.

(e) Give any two differences between reversible and irreversible processes with one example for each process.

(f) At what temperature will the average speed of molecules of H_2 gas be four times the average speed of O_2 molecules. (6x3)

2. (a) Show that for an adiabatic change in a perfect gas $TP^{\left(\frac{1-\gamma}{\gamma}\right)} = constant.$ (7)

(b) Show that for an adiabatic reversible process:

$$\frac{\partial T}{\partial v} = \frac{C_v - C_p}{\alpha v C_v}$$

where C_v, and C_p are the specific heat at constant volume and pressure respectively, v is the specific volume and α is the volume coefficient of expansion. (6)

(c) Prove that adiabatic elasticity of a gas is γ times the isothermal elasticity. (5)

3. (a) Give Kelvin-Planck and Clausius statements for second law of thermodynamics. Show that both the statements are equivalent to each other. (6)

(b) Show that the efficiency of a Carnot engine is dependent only on the temperatures of the source and sink by explaining the various cycles it undergoes. (8)

(c) A reversible engine converts one-fourth of heat into work. When the temperature of the sink is reduced by 50° C, it converts one half of heat input into work. Calculate the temperatures of the source and sink. (4)

4. (a) Starting from the Maxwell's thermodynamical relation prove that $C_P - C_v = \frac{T\alpha^2 v}{\beta_T}$

where C_v and C_p are the specific heat at constant volume and pressure respectively, T is the absolute temperature, β_T is the isothermal compressibility, α is the coefficient of volume expansion and v is the specific volume. (5)

(b) Derive Clausius-Clapeyron's equation

$$dP/dT = L/T(V_2 - V_1)$$

from Maxwell's the thermodynamical relations & also explain the effect of pressure on

(i) Boiling point of liquids and

(ii) Melting point of solids (6)

(c) Discuss in detail the concept of Clausius inequality and hence show that the difference in entropy for an irreversible process is greater than zero. (7)

5. (a) What do you mean by magneto-caloric effect? Giving a brief description of the experimental procedure, derive the expression for the fall in temperature of the specimen. Under what conditions will the fall in temperature would be more? (9)

(b) Show that when two phases of a one component system are in equilibrium, then specific Gibb's energies have the same value in both the phases. Hence, derive Ehrenfest's equations for the second order phase transitions. (9)

6. (a) Derive an expression for the mean free path and discuss its dependence on temperature and pressure. (6)

(b) Derive an expression for the coefficient of thermal conductivity using kinetic theory of gases. (9)

(c) Calculate the root mean square velocity of neutrons and electrons at 400K, taking the mass of neutron and electron as 1.675×10^{-27} kg and 9.11×10^{-31} kg respectively. (3)

7. (a) Discuss the results of Andrew's experiments on carbon dioxide. Hence, give a comparison of van der Waals' and Andrew's isotherms. (6)

(b) What do you mean by throttling process? Explain by giving a brief discussion of the experiment. Derive an expression for Joule-Thomson coefficient for ideal gases. (8)

(c) Calculate the drop in temperature when carbon dioxide gas suffers Joule-Thomson expansion at 30°C. The pressures on the two sides of the porous plug are given as 40 atm and 1 atm respectively. The van der Waals' constants of the gas are a =

36.5×10^{-2} Nm^4 mol^{-2}, b=5.28×10^{-5} m^{3}mol^{-1}.
(C_p=36.575 JK^{-1} mol^{-1} and R = 8.31 JK^{-1}mol^{-1})

(4)

Values of Constants:

Boltzmann's constant, $k = 1.38 \times 10^{-23}$ JK^{-1} Universal gas constant, R = 8.31 $Jmol^{-1}K^{-1}$

4817

[redacted]

Name of the Course: B.Sc. Physical Sciences - Core – CBCS

Semester: III

Name of the Paper: Thermal Physics and Statistical Mechanics

Unique Paper Code: 42224303

Duration: 3 Hours Maximum Marks: 75

Instruction for candidates

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

1. Attempt any *five* of the following: 5x3 = 15

(a) A quantity of air at 27^0C and at atmospheric pressure is suddenly compressed to half of its original volume. Find its final pressure.

(b) What do you mean by a thermodynamic system and thermodynamic coordinates? Give two examples of intensive and extensive coordinates.

(c) Draw and explain the T-S diagram of a Carnot's cycle.

(d) Define mean free path of a gas molecule. How does it vary with temperature and pressure?

(e) From Wein's displacement law, estimate the temperature of the Sun. Given λ_m= 4900 x 10^{-7} cm and Wein's constant = 0.292 cm K.

(f) Define phase space. What is the significance of a point in a phase space?

2 (a) Mention four stages of a Carnot cycle. State and prove Carnot's theorem.
(b) A Carnot's engine whose cold reservoir is at 7 ^{0}C has an efficiency of 50%. It is desired to increase the efficiency to 70%. By how many degrees should the temperature of hot reservoir be increased?

10,5

3 (a) What is entropy of a system? Give the mathematical form of the second law of thermodynamics. Show that the entropy of a system undergoing a reversible process remains constant whereas it always increases for an irreversible process.

(b) 10^{-3} kg of water at 20^0C is converted into ice at -10^0C at constant pressure. Calculate the total change in the entropy of the system. Given: sp. heat of ice = 0.5 $cal/g/K$, latent heat of ice = 80 cal/g.

10,5

4 (a) What is Joule-Thomson effect? Show that enthalpy remains constant during the porous plug experiment. Derive an expression for the Joule-Thomson coefficient?

(b) Using Maxwell's thermodynamic relation, derive Clausius-Clapeyron equation for phase transition.

10,5

5 (a) Using Maxwell's law of velocity distribution, derive expressions for

(i) average speed (v_{av})

(ii) most probable speed (v_{mp})

(iii) root mean square speed (v_{rms})

and show graphically that $v_{rms}>v_{av}>v_{mp}$.

(b) Describe a method for the experimental verification of Maxwell's law of distribution of velocity.

10,5

6 (a) What is a black body? What are the salient features of black body radiation?

(b) Derive Planck's formula for the spectral distribution of black body radiation.

(c) Two stars radiate maximum energy at wavelengths 3.6×10^{-7}m and 4.8×10^{-7}m respectively. What is the ratio of their temperatures?

4,8,3

7 (a) What are Fermions? Write down the postulates of Fermi-Dirac statistics. Derive an expression for the probability distribution of particles obeying Fermi-Dirac statistics.

(b) Three Fermions are to be distributed in four non-degenerate energy levels: ***a*, *b*, *c*** and ***d***. Calculate all possible ways of this distribution.

10,5

[This question paper contains 4 printed pages.]

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

Sr. No. of Question Paper : 4477 **G**

Unique Paper Code : 32227502

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

Name of the Course : **B.Sc. (Hons.) 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 taking at least **two** questions from each section.
3. **All** questions carry equal marks.

Section-A

1. (a) Prove that the set Q_{-1} of all rational numbers other than -1 with the binary operation * defined by $a * b = a + b + a b$ form a group. (5)

P.T.O.

(b) If V be the set of all ordered triples of reals, with addition and scalar multiplication defined as follows :–

$(x_1,y_1,z_1) + (x_2,y_2,z_2) = (3y_1 + 3y_2, -x_1 - x_2, z_1 + z_2)$

and $\alpha(x_1, y_1, z_1) = (3\alpha y_1, -\alpha x_1, \alpha z_1) \forall \alpha \in R$

then show that V is not a vector space. (5)

(c) Determine whether or not the vector $\xi = (2,-5,3)$ belonging to the subspace of R^3 spanned by $\alpha_1 = (1,-3,2)$, $\alpha_2 = (2,-4,1)$ and $\alpha_3 = (1,-5,7)$. (5)

2. (a) Verify that the vectors (1,3,2), (1,–7,–8), (2,1,–1) of v_3 space are linearly dependent. (5)

(b) Consider $T : R^3 \to R^2$ defined by $T(x,y,z) = (2x + 7y, 5y - 3z)$. Determine whether T is a linear transform or not. (5)

(c) If H is a Hermitian matrix, prove that e^{iH} is a unitary matrix $\left(i = \sqrt{-1}\right)$. (5)

3. (a) Find the eigenvalues and eigenvectors of the matrix

$$A = \begin{pmatrix} 1 & 0 & 1 \\ 0 & 3 & 2 \\ 0 & 0 & 2 \end{pmatrix}$$

Can A be diagonalized? If yes, find a diagonalizing matrix P and verify that P diagonalizes A. (10)

(b) Write Cayley-Hamilton theorem and verify it for the matrix

$$A = \begin{pmatrix} 3 & -4 \\ 1 & 5 \end{pmatrix}$$ (1,4)

4. (a) Solve the following system of differential equations using matrix method

$$y_1' = -y_1 + 4y_2$$
$$y_2' = 3y_1 - 2y_2$$

subject to $y_1(0) = 3$, $y_2(0) = 4$. (10)

(b) Find e^A for the matrix $A = \begin{pmatrix} 3 & -1 \\ 4 & -2 \end{pmatrix}$. (5)

Section-B

5. (a) Obtain an expression of pure stress tensor and prove that it is symmetric tensor of order (rank) two. (6)

(b) Show that $\vec{A} = \vec{B} \times \vec{C}$ transforms like a tensor of order (rank) one. (6)

(c) Prove that ε_{ijk} (in Cartesian Co-ordinates) is an isotopic tensor of order three. (3)

6. (a) Using Cartesian tensors, prove that

$$\nabla \cdot (\vec{A} \times \vec{B}) = (\nabla \times \vec{A}) \cdot \vec{B} - (\nabla \times \vec{B}) \cdot \vec{A}$$ (7)

(b) Show that $u_i v_j$ (in Cartesian Co-ordinates) is a tensor of order (rank) two. (3)

(c) By using the expression of Moment of Inertia of an asymmetric object

$$I_{ik} = \sum_{\text{all particles}} m\left(r^2\delta_{ik} - r_i r_k\right),$$

from a matrix of all components. What is the all meaning of I_{xy}? (4,1)

7. (a) A covariant tensor has components xy, $2y - z^2$, xz in Cartesian Co-ordinates. Find its covariant components in cylindrical co-ordinates. (12)

(b) Determine the metric tensor in Spherical Co-ordinates. (3)

8. (a) If A_k^{ij} and B_q^{p} are general tensors, show that $A_k^{ij} B_q^{i}$ is not a tensor. (6)

(b) Show that the outer product of two contravariant vectors A^{μ} and B^{ν} results in a contavariant tensor of rank two. (4)

(c) Show that every covariant tensor of order two can be expressed as the sum of two tensors, one of which is symmetric and the other skew-symmetric. (5)

Sl No of QP :**4286**

Unique Paper Code : 32223904

Name of the Paper : Basic Instrumentation Skills

Name of the Course : B.Sc. Hons/Prog-CBCS-LOCF

Semester : V

Duration : 3 hours

Maximum Marks : 50

Instructions for Candidates:-

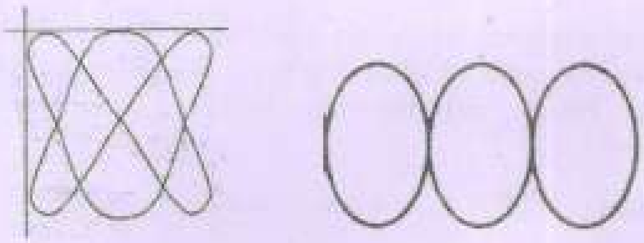
(Write your roll No. on the top immediately on the receipt of the paper)

Attempt any Five questions in all.

Question No. 1 is compulsory.

Q1 Attempt **any five** of the following. (2x5=10)

(a) Find the ratio of frequency in the following diagrams:



?

(b) How would 0.2356 V be displayed on a 1V and 10 V ranges of a digital voltmeter having a $4\frac{1}{2}$ digit display?

(c) Write two advantages of electronic voltmeter over conventional voltmeter.

(d) What is the difference between dual beam and dual trace CRO?

(e) Define the resolution and sensitivity of a digital meter.

(f) What is the difference between a pulse and square wave generator?

(g) On what principle is Q-meter based?

Q2 (a) Explain what is gross, random and systematic error in measurement system. How can these errors be minimized? (6)

(b) Three resistors have the following ratings:

R1 = 50 Ω ± 2%, R2 = 500 Ω ± 5%, R3 = 100 Ω ± 3%

Determine the magnitude and limiting error in ohms and in per cent of the resistance of these resistances when connected in series. (4)

Q3 (a) (a) Draw the block diagram of a general purpose CRO and explain briefly the function of each block. (7)

(b) What are Lissajous figures? On what factor does its shape depend? (3)

Q4 (a) What are the advantages of using digital instruments over analog? Explain the working principle of digital voltmeter. (6)

(b) A D'Arsonval movement with a full scale deflection current of 50μA and internal resistance of 1 kΩ is to be converted into multi range voltmeter. Calculate the value of multiplier resistor required for voltage range of (i) (0-25) V (ii) (0-100) V (4)

Q5 (a) Explain the working of a digital multimeter with the help of block diagram. (5)

(b) Explain with suitable example what is loading effect of an ammeter. (5)

Q6 (a) Draw the circuit diagram of a general AC bridge and deduce the equations for its balance. What physical quantities can be measured using the following bridges i) Maxwell Bridge ii) Hay Bridge iii) Schering Bridge iv) Wien-bridge. (6)

(b) Explain the working of a basic wave analyser circuit. (4)

22/12/23
(M)

[This question paper contains 8 printed pages.]

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

Sr. No. of Question Paper : 4979 **G**

Unique Paper Code : 42227929

Name of the Paper : Elements of Modern Physics

Name of the Course : **B.Sc. (Prog.) Physical Science – (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 **five** questions in all.
3. Question No. **1** is compulsory.
4. **All** questions carry equal marks.
5. Non-programmable scientific calculators are allowed.

P.T.O.

1. All parts are compulsory : (3×5=15)

(a) A metal whose work function is 4.2 eV is irradiated by radiation of 2000 Å wavelength. Find the maximum kinetic energy of emitted electrons.

(b) Estimate the minimum uncertainty in the velocity of a proton confined in a nucleus of radius 10^{-14} m.

(c) A wave function of a particle is given by $\psi(x) = Ae^{-kx}$ over the domain $0 \le x \le \infty$ (Assume $\psi(x) = 0$ outside this domain.), where A and k are constants. Find the normalization constant A in terms of k.

(d) The wavefunction associated with a particle is given as $\psi(x)=\sqrt{\frac{2}{L}}\sin\left(\frac{3\pi x}{L}\right)$ in region $0 \le x \le L$, and $\psi(x) = 0$ otherwise. Calculate the probability of finding the particle in interval $\frac{L}{3} \le x \le \frac{2L}{3}$.

(e) Write salient features of nuclear forces.

2. (a) Show that the de Broglie wavelength associated with electron which is accelerated from rest through a potential difference V volt (non-relativistic case) is

$$\lambda = \frac{12.3}{\sqrt{V}} \text{Å} .$$

(b) A photon of energy 3 keV collides with an electron initially at rest. If the photon emerges at an angle 60°, calculate the angle at which the electron recoils.

(c) In a typical Davisson-Germer experiment, the first maxima in the diffraction pattern of 54 eV electrons was observed at $\phi = 60°$ from an unknown target, where ϕ is the angle between the incident and scattered beams. Determine the lattice constant D of the target. (5,5,5)

3. (a) What is energy-time uncertainty principle? Discuss the gamma ray microscope thought experiment and explain how it validates Heisenberg's uncertainty principle.

(b) Calculate series limit wavelengths corresponding to Balmer and Paschen series of hydrogen spectra. (10,5)

4. (a) A particle of mass m is confined in a one dimensional infinitely rigid box having potential

$$V(x) = \begin{cases} \infty & x < -L/2 \\ 0 & -L/2 \le x \le L/2 \\ \infty & x > L/2 \end{cases}$$

Find the wave functions associated with the particle and its energy E.

(b) When light of given wavelength is incident on a metallic surface, the stopping potential for the photoelectrons is 3.2 V. If a second light source

whose wavelength is double that of the first is used, the stopping potential drops to 0.8 V. Calculate the work function and the cut-off frequency of the metal. (10,5)

5. (a) A particle of mass m and energy $E < V_0$ travelling along x-axis has a potential barrier defined by

$$V(x) = \begin{cases} 0 & x < 0 \\ V_0 & 0 < x < L \\ 0 & x > 0 \end{cases}$$

Write Schrodinger equations and their solutions for three regions, explain each term of the solutions.

(b) The transmission probability of an electron across a potential barrier of 10 eV is equal to 0.8%. If the width of the potential barrier is 0.6 nm, calculate the energy of incident electron using the approximate formula.

(c) Calculate the de Broglie wavelength for a proton of kinetic energy 70 MeV. (5,5,5)

6. (a) For following wavefunction

$$\psi(x, t) = A(\sin kx + iB\cos kx)e^{-i\omega t}$$

where A, B, k, ω are real constants. Calculate probability density and probability current density.

(b) The time-independent wave function of a particle of mass m moving in a potential $V(x) = \alpha^2 x^2$ is

$$\psi(x) = \exp\left(-\sqrt{\frac{m\alpha^2}{2\hbar^2}}x^2\right)$$, α being a constant. Find

the energy of the system. (10,5)

7. (a) What is positive beta decay and negative beta decay? Explain giving examples.

(b) One gram of ^{226}Ra has an activity of 1 curie. From this fact determine the half life of ^{226}Ra. How much time will it take to decay 0.75 g of ^{226}Ra?

(c) The nucleus $^{23}_{10}$Ne decays by negative beta-emission. Determine the maximum kinetic energy (in Joule) of the electrons emitted. Given that :

$m(^{23}_{10}Ne) = 22.994466\ u$

$m(^{23}_{11}Na) = 22.089770\ u$. (5,5,5)

Constants :

$h = 6.62 \times 10^{-34}$ J.s

$c = 3 \times 10^{8}$ m/s

$e = 1.6 \times 10^{-19}$ C

$m_e = 9.1 \times 10^{-31}$ kg

$m_n = 1.6749 \times 10^{-27}$ kg = 1.00866 u

$m_p = 1.6726 \times 10^{-27}$ kg = 1.00728 u

$R = 1.097 \times 10^{7}$ m^{-1}

[This question paper contains 4 printed pages.]

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

Sr. No. of Question Paper : 4595 **G**

Unique Paper Code : 32227504

Name of the Paper : Nuclear and Particle Physics

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

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.
3. Question No. **1** is compulsory.
4. Use of scientific calculators is allowed.
5. Some useful data is given at the end.

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

   (a) How do gamma rays and neutrons interact with matter?

   (b) Show that the nuclear density is same for all the nuclei.

P.T.O.

(c) Calculate the w-value of the incident alpha particle whose energy is 1 MeV of a gas filled detector that produces 3.3×10^4 ion-pairs.

(d) Explain the terms nuclear magnetic dipole moment and the nuclear electric quadrupole moment.

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

(f) Represent the Geiger Nuttall law graphically.

(3×5=15)

2. (a) Explain the terms: mass defect and binding energy of the nucleus. Discuss the variation of the binding energy with atomic mass number A with the help of graph between binding energy per nucleon and mass number. (10)

(b) The mass of a deuteron is 2.014103 amu. Find the mass defect and packing fraction. (5)

3. (a) Discuss the shell model of the nucleus. What are its merits and demerits? (10)

(b) Draw schematic shell model diagram for the following nuclei, showing the filling-up of the levels by protons and neutrons for $^{40}_{20}Ca$. (5)

4. (a) In terms of the parent and daughter rest masses and the rest masses of the β^+, β^- particles, determine the Q values for β^+-decay, β^--decay and electron capture. (8)

(b) Find the minimum kinetic energy in the laboratory system, needed by an alpha particle to cause the reaction

$$^{14}_{7}N + ^{4}_{2}He \rightarrow ^{1}_{1}H + ^{17}_{8}O.$$ (7)

5. (a) What are the basic assumptions of Gamow's theory of alpha decay? Represent graphically the potential energy of an alpha particle within the nucleus and outside the nucleus. (8)

(b) Define Q, the disintegration energy of a nuclear reaction. Discuss the significance of $Q > 0$, $Q < 0$ and $Q = 0$. (5)

(c) If the energy of the incident particle hitting a stationary target is less than the threshold energy, what will be the valueof the cross section of this nuclear reaction? (2)

6. (a) How do γ-rays interact with matter? Derive the law of absorption of γ-rays in matter and define the linear absorption co-efficient and the mass absorption co-efficient of the matter. (2+8)

(b) In an absorption experiment with 1.14 MeV γ-radiation from $^{65}_{30}Zn$, it is found that 25 cm thick sheet of aluminum reduces the beam intensity to 2%. Calculate the linear absorption co-efficient and the mass absorption co-efficient of aluminum for this radiation. Density of aluminum is 2700 kg/m^3. (5)

7. (a) Explain the construction and working of linear accelerator (LINAC). For a LINAC, obtain the velocity of the emergent ion at n^{th} tube and length of this tube. (5+5)

(b) Protons are accelerated in a drift tube portion of a LINAC from 0.75 MeV to 100 MeV and if the length of the first tube is 3 cm. Find the frequency of applied AC voltage in MHz. (5)

Some useful data

1 amu = 931.5 MeV

Masses:

Atomic mass of proton (m_p) = 1.007825 amu,

Atomic mass of neutron (m_n) = 1.008663 amu

Atomic mass of Hydrogen ($^{1}_{1}H$) = 1.007825 amu

Atomic mass of Helium ($^{4}_{2}He$) = 4.002603 amu

Atomic mass of Nitrogen ($^{14}_{7}N$) = 14.00307 amu

Atomic mass of Oxygen ($^{17}_{8}O$) = 16.99913 amu

Atomic mass of Calcium ($^{40}_{20}Ca$) = 40.078 amu

Atomic mass of Zinc ($^{65}_{30}Zn$) = 65.38 amu

[This question paper contains 8 printed pages.]

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

Sr. No. of Question Paper : 4334 **G**

Unique Paper Code : 32221501

Name of the Paper : Quantum Mechanics and Applications

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 .
3. **Question No. 1** is compulsory.
4. All questions carry equal marks
5. Non programmable calculators allowed

1. Attempt **any five** of the following

   (a) Verify whether the following operators are Hermitian:

(i) $-i\hbar\frac{d}{dx}$

(ii) Hamiltonian of free particle

(iii) Hamiltonian of a particle in a I-d harmonic oscillator potential.

(b) Evaluate the following commutators : if $[\hat{x}, \hat{p}_x] = i\hbar$

(i) $[\hat{P}_x, \hat{L}_x]$

(ii) $[\hat{L}_i, \hat{L}^2]; i = x, y, z$

(iii) $[\hat{H}, \hat{L}^2]$

(c) What are the stationary states? Why they are so called?

(d) Find the momentum space wave function corresponding to $e^{-\alpha x}$.

(e) A particle is represented by the wave function $\psi\ (x,\ 0) = A(a^2 - x^2)$ if $-a \leq x \leq a$ and $\psi\ (x,\ 0) = 0$, otherwise. Find the uncertainty in p.

(f) Assume that a magnetic dipole, whose moment has magnitude μ_l, is aligned parallel to external magnetic field whose strength has magnitude B. Take μ_l = 1 Bohr magneton and $B = 1T$. Calculate the energy required to turn the magnetic dipole so that it is aligned antiparallel to the field.

(5×3=15)

2. (a) Consider a one-dimentional infinite potential well of width L. The wave function is given by

$$\Psi(x,0) = \begin{cases} 3\phi_1(x) + 4\phi_2(x) & \textit{inside the well} \\ 0 & \textit{outside the well} \end{cases}$$

where $\phi_1(x)$ and $\phi_2(x)$ are normalized wavefunctions of the ground state and first excited state.

(i) Normalize $\psi\ (x,\ 0)$.

(ii) Find the average energy of the particle.

(iii) Write down $\psi(x, t)$.

(iv) Find the probability of finding the particle in the interval [0, L/2] at two different times,

$$t = \frac{\hbar}{3E_1}\cdot\frac{\pi}{2} \text{ and } t = \frac{\hbar}{3E_1}\cdot\pi.\ 4$$

(b) A particle of mass m, which moves freely inside an infinite potential well of length 'a', is initially in the state: $\Psi(x,0) = \sqrt{\frac{1}{5a}}\sin(\frac{\pi x}{a}) + \sqrt{\frac{3}{5a}}\sin(\frac{3\pi x}{a})$

(a) Find $\psi(x, t)$ at any later time t.

(b) If the energy is measured, what are the possible values of energies with what probabilities? (9, 6)

3. (a) Solve the Schrodinger equation for a Linear Harmonic Oscillator. Obtain and plot first three eigenfunctions. Calculate the number of node in first three eigen functions. Also explain why they are symmetric and antisymmetric.

(b) Calculate the uncertainty in momentum and position for the ground state eigenfunction of linear Harmonic Oscillator and hence obtain uncertainty relation. (8, 7)

4. (a) Write the Schrodinger equation for a 3D hydrogen atom in spherical polar coordinates. Derive three separate equations for r, θ, ϕ using the method of separation of variables. Solve the equation for ϕ to obtain the normalized eigenfunctions and show that they are orhogonal.

(b) Show that the fractional difference in the energy between adjacent eigenvalues $\frac{\Delta E_n}{E_n}$ proportional to $\frac{1}{n^3}$ for a large value of n . Explain the meaning of degeneracy. Show that degree of degeneracy of nth energy level is given by $2n^2$ in hydrogen atom. (9, 6)

5. (a) The ground state wave function of hydrogen atom is : $\psi(r) = \frac{1}{\sqrt{\pi a_0^3}} \exp(-r/a_0)$

   (i) Calculate the expectation value $<r>$ and $<\frac{1}{r}>$ in the ground state of Hydrogen atom.

   (ii) Calculate the probability of finding the particle at a distance less than a_0.

   (iii) Write the wave function $\psi(r)$ and energy eigen value E_n for hydrogenic atom having at Z charge and principle quantum n.

(b) Apply L_z on the wave function $\psi_{2}1\text{-}1$ for the hydrogen atom and find the eigen value of L_z and corresponding eigen function.

Given : $\psi_{21-1} = \frac{1}{8\sqrt{\pi}} \cdot (\frac{1}{a_0})^{3/2} \frac{r}{a_0} \cdot e^{-r/2a_0} \cdot \sin\theta e^{-i\phi}$

(9, 6)

6. (a) Draw the energy level diagram to show the Zeeman splitting of the ground and first excited states of sodium in a week magnetic field. Also show the transitions allowed by the selection rules.

   (b) Describe Stern Gerlach Experiment with necessary theory. What does it demonstrate? (7, 8)

7. (a) Find the terms for 3p4d configuration system in LS Coupling. Show them in diagram. (5)

   (b) Is $^2D_{1/2}$ a possible term? Calculate the angle between vector I and vector s in the $^2P_{3/2}$ state of a one electron atom. (5)

(c) What is space quantization? Calculate the possible orientations of the total angular momentum vector J corresponding to j=3/2 with respect to a magnetic field along the z axis. (5)

Useful integral

$$\int_{-\infty}^{+\infty} dx\, exp(-\alpha x^2 + \beta x) = \sqrt{\frac{\pi}{\alpha}} \exp(\beta^2/4\alpha)$$

$$\int_{0}^{+\infty} dx x^n\, exp(-\alpha x) = \frac{n!}{\alpha^{n+1}}$$

[This question paper contains 4 printed pages.]

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

Sr. No. of Question Paper : 4477 **G**

Unique Paper Code : 32227502

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

Name of the Course : **B.Sc. (Hons.) 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 taking at least **two** questions from each section.
3. **All** questions carry equal marks.

Section-A

1. (a) Prove that the set Q_{-1} of all rational numbers other than -1 with the binary operation * defined by $a * b = a + b + a b$ form a group. (5)

P.T.O.

(b) If V be the set of all ordered triples of reals, with addition and scalar multiplication defined as follows :–

$(x_1,y_1,z_1) + (x_2,y_2,z_2) = (3y_1 + 3y_2, -x_1 - x_2, z_1 + z_2)$

and $\alpha(x_1, y_1, z_1) = (3\alpha y_1, -\alpha x_1, \alpha z_1) \forall \alpha \in R$

then show that V is not a vector space. (5)

(c) Determine whether or not the vector $\xi = (2,-5,3)$ belonging to the subspace of R^3 spanned by $\alpha_1 = (1,-3,2)$, $\alpha_2 = (2,-4,1)$ and $\alpha_3 = (1,-5,7)$. (5)

2. (a) Verify that the vectors (1,3,2), (1,–7,–8), (2,1,–1) of v_3 space are linearly dependent. (5)

(b) Consider $T : R^3 \to R^2$ defined by $T(x,y,z) = (2x + 7y, 5y - 3z)$. Determine whether T is a linear transform or not. (5)

(c) If H is a Hermitian matrix, prove that e^{iH} is a unitary matrix $\left(i = \sqrt{-1}\right)$. (5)

3. (a) Find the eigenvalues and eigenvectors of the matrix

$$A = \begin{pmatrix} 1 & 0 & 1 \\ 0 & 3 & 2 \\ 0 & 0 & 2 \end{pmatrix}$$

Can A be diagonalized? If yes, find a diagonalizing matrix P and verify that P diagonalizes A. (10)

(b) Write Cayley-Hamilton theorem and verify it for the matrix

$$A = \begin{pmatrix} 3 & -4 \\ 1 & 5 \end{pmatrix}$$ (1,4)

4. (a) Solve the following system of differential equations using matrix method

$$y_1' = -y_1 + 4y_2$$
$$y_2' = 3y_1 - 2y_2$$

subject to $y_1(0) = 3$, $y_2(0) = 4$. (10)

(b) Find e^A for the matrix $A = \begin{pmatrix} 3 & -1 \\ 4 & -2 \end{pmatrix}$. (5)

Section-B

5. (a) Obtain an expression of pure stress tensor and prove that it is symmetric tensor of order (rank) two. (6)

(b) Show that $\vec{A} = \vec{B} \times \vec{C}$ transforms like a tensor of order (rank) one. (6)

(c) Prove that ε_{ijk} (in Cartesian Co-ordinates) is an isotopic tensor of order three. (3)

6. (a) Using Cartesian tensors, prove that

$$\nabla \cdot (\vec{A} \times \vec{B}) = (\nabla \times \vec{A}) \cdot \vec{B} - (\nabla \times \vec{B}) \cdot \vec{A}$$ (7)

(b) Show that $u_i v_j$ (in Cartesian Co-ordinates) is a tensor of order (rank) two. (3)

(c) By using the expression of Moment of Inertia of an asymmetric object

$$I_{ik} = \sum_{\text{all particles}} m\left(r^2\delta_{ik} - r_i r_k\right),$$

from a matrix of all components. What is the all meaning of I_{xy}? (4,1)

7. (a) A covariant tensor has components xy, $2y - z^2$, xz in Cartesian Co-ordinates. Find its covariant components in cylindrical co-ordinates. (12)

(b) Determine the metric tensor in Spherical Co-ordinates. (3)

8. (a) If A^{ij}_{k} and B^{p}_{q} are general tensors, show that $A^{ij}_{k} B^{l}_{q}$ is not a tensor. (6)

(b) Show that the outer product of two contravariant vectors A^{μ} and B^{ν} results in a contavariant tensor of rank two. (4)

(c) Show that every covariant tensor of order two can be expressed as the sum of two tensors, one of which is symmetric and the other skew-symmetric. (5)

(1000)

Sl No of QP :**4286**

Unique Paper Code : 32223904

Name of the Paper : Basic Instrumentation Skills

Name of the Course : B.Sc. Hons/Prog-CBCS-LOCF

Semester : V

Duration : 3 hours

Maximum Marks : 50

Instructions for Candidates:-

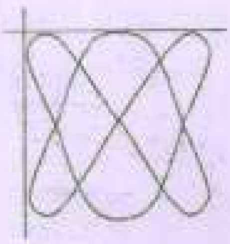
(Write your roll No. on the top immediately on the receipt of the paper)

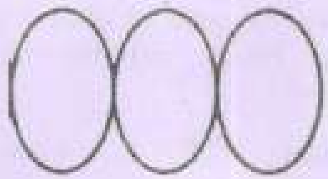
Attempt any Five questions in all.

Question No. 1 is compulsory.

Q1 Attempt **any five** of the following. (2x5=10)

(a) Find the ratio of frequency in the following diagrams:





?

(b) How would 0.2356 V be displayed on a 1V and 10 V ranges of a digital voltmeter having a $4\frac{1}{2}$ digit display?

(c) Write two advantages of electronic voltmeter over conventional voltmeter.

(d) What is the difference between dual beam and dual trace CRO?

(e) Define the resolution and sensitivity of a digital meter.

(f) What is the difference between a pulse and square wave generator?

(g) On what principle is Q-meter based?

Q2 (a) Explain what is gross, random and systematic error in measurement system. How can these errors be minimized? (6)

(b) Three resistors have the following ratings:

R1 = 50 Ω ± 2%, R2 = 500 Ω ± 5%, R3 = 100 Ω ± 3%

Determine the magnitude and limiting error in ohms and in per cent of the resistance of these resistances when connected in series. (4)

Q3 (a) (a) Draw the block diagram of a general purpose CRO and explain briefly the function of each block. (7)

(b) What are Lissajous figures? On what factor does its shape depend? (3)

Q4 (a) What are the advantages of using digital instruments over analog? Explain the working principle of digital voltmeter. (6)

(b) A D'Arsonval movement with a full scale deflection current of 50μA and internal resistance of 1 kΩ is to be converted into multi range voltmeter. Calculate the value of multiplier resistor required for voltage range of (i) (0-25) V (ii) (0-100) V (4)

Q5 (a) Explain the working of a digital multimeter with the help of block diagram. (5)

(b) Explain with suitable example what is loading effect of an ammeter. (5)

Q6 (a) Draw the circuit diagram of a general AC bridge and deduce the equations for its balance. What physical quantities can be measured using the following bridges i) Maxwell Bridge ii) Hay Bridge iii) Schering Bridge iv) Wien-bridge. (6)

(b) Explain the working of a basic wave analyser circuit. (4)

22/12/23
(M)

[This question paper contains 8 printed pages.]

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

Sr. No. of Question Paper : 4979 **G**

Unique Paper Code : 42227929

Name of the Paper : Elements of Modern Physics

Name of the Course : **B.Sc. (Prog.) Physical Science – (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 **five** questions in all.
3. Question No. **1** is compulsory.
4. **All** questions carry equal marks.
5. Non-programmable scientific calculators are allowed.

P.T.O.

1. All parts are compulsory : (3×5=15)

(a) A metal whose work function is 4.2 eV is irradiated by radiation of 2000 Å wavelength. Find the maximum kinetic energy of emitted electrons.

(b) Estimate the minimum uncertainty in the velocity of a proton confined in a nucleus of radius 10^{-14} m.

(c) A wave function of a particle is given by $\psi(x) = Ae^{-kx}$ over the domain $0 \le x \le \infty$ (Assume $\psi(x) = 0$ outside this domain.), where A and k are constants. Find the normalization constant A in terms of k.

(d) The wavefunction associated with a particle is given as $\psi(x)=\sqrt{\frac{2}{L}}\sin\left(\frac{3\pi x}{L}\right)$ in region $0 \le x \le L$, and $\psi(x) = 0$ otherwise. Calculate the probability of finding the particle in interval $\frac{L}{3} \le x \le \frac{2L}{3}$.

(e) Write salient features of nuclear forces.

2. (a) Show that the de Broglie wavelength associated with electron which is accelerated from rest through a potential difference V volt (non-relativistic case) is

$$\lambda = \frac{12.3}{\sqrt{V}} Å .$$

(b) A photon of energy 3 keV collides with an electron initially at rest. If the photon emerges at an angle 60°, calculate the angle at which the electron recoils.

(c) In a typical Davisson-Germer experiment, the first maxima in the diffraction pattern of 54 eV electrons was observed at $\phi = 60°$ from an unknown target, where ϕ is the angle between the incident and scattered beams. Determine the lattice constant D of the target. (5,5,5)

3. (a) What is energy-time uncertainty principle? Discuss the gamma ray microscope thought experiment and explain how it validates Heisenberg's uncertainty principle.

(b) Calculate series limit wavelengths corresponding to Balmer and Paschen series of hydrogen spectra. (10,5)

4. (a) A particle of mass m is confined in a one dimensional infinitely rigid box having potential

$$V(x) = \begin{cases} \infty & x < -L/2 \\ 0 & -L/2 \le x \le L/2 \\ \infty & x > L/2 \end{cases}$$

Find the wave functions associated with the particle and its energy E.

(b) When light of given wavelength is incident on a metallic surface, the stopping potential for the photoelectrons is 3.2 V. If a second light source

whose wavelength is double that of the first is used, the stopping potential drops to 0.8 V. Calculate the work function and the cut-off frequency of the metal. (10,5)

5. (a) A particle of mass m and energy $E < V_0$ travelling along x-axis has a potential barrier defined by

$$V(x) = \begin{cases} 0 & x < 0 \\ V_0 & 0 < x < L \\ 0 & x > 0 \end{cases}$$

Write Schrodinger equations and their solutions for three regions, explain each term of the solutions.

(b) The transmission probability of an electron across a potential barrier of 10 eV is equal to 0.8%. If the width of the potential barrier is 0.6 nm, calculate the energy of incident electron using the approximate formula.

(c) Calculate the de Broglie wavelength for a proton of kinetic energy 70 MeV. (5,5,5)

6. (a) For following wavefunction

$$\psi(x, t) = A(\sin kx + iB\cos kx)e^{-i\omega t}$$

where A, B, k, ω are real constants. Calculate probability density and probability current density.

(b) The time-independent wave function of a particle of mass m moving in a potential $V(x) = \alpha^2 x^2$ is

$$\psi(x) = \exp\left(-\sqrt{\frac{m\alpha^2}{2\hbar^2}}x^2\right)$$, α being a constant. Find

the energy of the system. (10,5)

7. (a) What is positive beta decay and negative beta decay? Explain giving examples.

(b) One gram of ^{226}Ra has an activity of 1 curie. From this fact determine the half life of ^{226}Ra. How much time will it take to decay 0.75 g of ^{226}Ra?

(c) The nucleus $^{23}_{10}$Ne decays by negative beta-emission. Determine the maximum kinetic energy (in Joule) of the electrons emitted. Given that :

$$m(^{23}_{10}Ne) = 22.994466\,u$$

$$m(^{23}_{11}Na) = 22.089770\,u.$$ (5,5,5)

Constants :

$h = 6.62 \times 10^{-34}$ J.s

$c = 3 \times 10^{8}$ m/s

$e = 1.6 \times 10^{-19}$ C

$m_e = 9.1 \times 10^{-31}$ kg

$m_n = 1.6749 \times 10^{-27}$ kg = 1.00866 u

$m_p = 1.6726 \times 10^{-27}$ kg = 1.00728 u

$R = 1.097 \times 10^{7}$ m^{-1}

[This question paper contains 4 printed pages.]

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

Sr. No. of Question Paper : 4595 **G**

Unique Paper Code : 32227504

Name of the Paper : Nuclear and Particle Physics

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

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.
3. Question No. **1** is compulsory.
4. Use of scientific calculators is allowed.
5. Some useful data is given at the end.

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

   (a) How do gamma rays and neutrons interact with matter?

   (b) Show that the nuclear density is same for all the nuclei.

(c) Calculate the w-value of the incident alpha particle whose energy is 1 MeV of a gas filled detector that produces 3.3×10^4 ion-pairs.

(d) Explain the terms nuclear magnetic dipole moment and the nuclear electric quadrupole moment.

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

(f) Represent the Geiger Nuttall law graphically. $(3\times5=15)$

2. (a) Explain the terms: mass defect and binding energy of the nucleus. Discuss the variation of the binding energy with atomic mass number A with the help of graph between binding energy per nucleon and mass number. (10)

(b) The mass of a deuteron is 2.014103 amu. Find the mass defect and packing fraction. (5)

3. (a) Discuss the shell model of the nucleus. What are its merits and demerits? (10)

(b) Draw schematic shell model diagram for the following nuclei, showing the filling-up of the levels by protons and neutrons for ${}^{40}_{20}Ca$. (5)

4. (a) In terms of the parent and daughter rest masses and the rest masses of the β^+, β^- particles, determine the Q values for β^+-decay, β^--decay and electron capture. (8)

(b) Find the minimum kinetic energy in the laboratory system, needed by an alpha particle to cause the reaction

$${}^{14}_{7}N + {}^{4}_{2}He \rightarrow {}^{1}_{1}H + {}^{17}_{8}O. \quad (7)$$

5. (a) What are the basic assumptions of Gamow's theory of alpha decay? Represent graphically the potential energy of an alpha particle within the nucleus and outside the nucleus. (8)

(b) Define Q, the disintegration energy of a nuclear reaction. Discuss the significance of $Q > 0$, $Q < 0$ and $Q = 0$. (5)

(c) If the energy of the incident particle hitting a stationary target is less than the threshold energy, what will be the valueof the cross section of this nuclear reaction? (2)

6. (a) How do γ-rays interact with matter? Derive the law of absorption of γ-rays in matter and define the linear absorption co-efficient and the mass absorption co-efficient of the matter. (2+8)

(b) In an absorption experiment with 1.14 MeV γ-radiation from $^{65}_{30}Zn$, it is found that 25 cm thick sheet of aluminum reduces the beam intensity to 2%. Calculate the linear absorption co-efficient and the mass absorption co-efficient of aluminum for this radiation. Density of aluminum is 2700 kg/m^3. (5)

7. (a) Explain the construction and working of linear accelerator (LINAC). For a LINAC, obtain the velocity of the emergent ion at n^{th} tube and length of this tube. (5+5)

(b) Protons are accelerated in a drift tube portion of a LINAC from 0.75 MeV to 100 MeV and if the length of the first tube is 3 cm. Find the frequency of applied AC voltage in MHz. (5)

Some useful data

1 amu = 931.5 MeV

<u>Masses:</u>

Atomic mass of proton (m_p) = 1.007825 amu,

Atomic mass of neutron (m_n) = 1.008663 amu

Atomic mass of Hydrogen ($^{1}_{1}H$) = 1.007825 amu

Atomic mass of Helium ($^{4}_{2}He$) = 4.002603 amu

Atomic mass of Nitrogen ($^{14}_{7}N$) = 14.00307 amu

Atomic mass of Oxygen ($^{17}_{8}O$) = 16.99913 amu

Atomic mass of Calcium ($^{40}_{20}Ca$) = 40.078 amu

Atomic mass of Zinc ($^{65}_{30}Zn$) = 65.38 amu

[This question paper contains 8 printed pages.]

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

Sr. No. of Question Paper : 4334 **G**

Unique Paper Code : 32221501

Name of the Paper : Quantum Mechanics and Applications

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 .
3. **Question No. 1** is compulsory.
4. All questions carry equal marks
5. Non programmable calculators allowed

1. Attempt **any five** of the following

(a) Verify whether the following operators are Hermitian:

P.T.O.

(i) $-i\hbar\frac{d}{dx}$

(ii) Hamiltonian of free particle

(iii) Hamiltonian of a particle in a 1-d harmonic oscillator potential.

(b) Evaluate the following commutators : if $[\hat{x},\hat{p}_x]=i\hbar$

(i) $[\hat{P}_x,\hat{L}_x]$

(ii) $[\hat{L}_i,\hat{L}^2]; i=x,y,z$

(iii) $[\hat{H},\hat{L}^2]$

(c) What are the stationary states? Why they are so called?

(d) Find the momentum space wave function corresponding to $e^{-\alpha x}$.

(e) A particle is represented by the wave function $\psi(x,0)=A(a^2-x^2)$ if $-a\le x\le a$ and $\psi(x,0)=0$, otherwise. Find the uncertainty in p.

(f) Assume that a magnetic dipole, whose moment has magnitude μ_l, is aligned parallel to external magnetic field whose strength has magnitude B. Take μ_l = 1 Bohr magneton and $B=1T$. Calculate the energy required to turn the magnetic dipole so that it is aligned antiparallel to the field.

(5×3=15)

2. (a) Consider a one-dimentional infinite potential well of width L. The wave function is given by

$$\Psi(x,0)=\begin{cases}3\phi_1(x)+4\phi_2(x) & \textit{inside the well}\\ 0 & \textit{outside the well}\end{cases}$$

where $\phi_1(x)$ and $\phi_2(x)$ are normalized wavefunctions of the ground state and first excited state.

(i) Normalize $\psi(x,0)$.

(ii) Find the average energy of the particle.

(iii) Write down $\psi(x, t)$.

(iv) Find the probability of finding the particle in the interval [0, L/2] at two different times,

$$t = \frac{\hbar}{3E_1}\cdot\frac{\pi}{2} \text{ and } t = \frac{\hbar}{3E_1}\cdot\pi.\ 4$$

(b) A particle of mass m, which moves freely inside an infinite potential well of length 'a', is initially in the state: $\Psi(x,0) = \sqrt{\frac{1}{5a}}\sin(\frac{\pi x}{a}) + \sqrt{\frac{3}{5a}}\sin(\frac{3\pi x}{a})$

(a) Find $\psi(x, t)$ at any later time t.

(b) If the energy is measured, what are the possible values of energies with what probabilities? (9, 6)

3. (a) Solve the Schrodinger equation for a Linear Harmonic Oscillator. Obtain and plot first three eigenfunctions. Calculate the number of node in first three eigen functions. Also explain why they are symmetric and antisymmetric.

(b) Calculate the uncertainty in momentum and position for the ground state eigenfunction of linear Harmonic Oscillator and hence obtain uncertainty relation. (8, 7)

4. (a) Write the Schrodinger equation for a 3D hydrogen atom in spherical polar coordinates. Derive three separate equations for r, θ, ϕ using the method of separation of variables. Solve the equation for ϕ to obtain the normalized eigenfunctions and show that they are orhogonal.

(b) Show that the fractional difference in the energy between adjacent eigenvalues $\frac{\Delta E_n}{E_n}$ proportional to $\frac{1}{n^3}$ for a large value of n. Explain the meaning of degeneracy. Show that degree of degeneracy of nth energy level is given by $2n^2$ in hydrogen atom. (9, 6)

5. (a) The ground state wave function of hydrogen atom is : $\psi(r) = \frac{1}{\sqrt{\pi a_0^3}} \exp(-r/a_0)$

(i) Calculate the expectation value $<r>$ and $<\frac{1}{r}>$ in the ground state of Hydrogen atom.

(ii) Calculate the probability of finding the particle at a distance less than a_0.

(iii) Write the wave function $\psi(r)$ and energy eigen value E_n for hydrogenic atom having at Z charge and principle quantum n.

(b) Apply L_z on the wave function $\psi_{2,1-1}$ for the hydrogen atom and find the eigen value of L_z and corresponding eigen function.

Given : $\psi_{21-1} = \frac{1}{8\sqrt{\pi}} \cdot (\frac{1}{a_0})^{3/2} \frac{r}{a_0} \cdot e^{-r/2a_0} \cdot \sin\theta e^{-i\phi}$

(9, 6)

6. (a) Draw the energy level diagram to show the Zeeman splitting of the ground and first excited states of sodium in a week magnetic field. Also show the transitions allowed by the selection rules.

(b) Describe Stern Gerlach Experiment with necessary theory. What does it demonstrate? (7, 8)

7. (a) Find the terms for 3p4d configuration system in LS Coupling. Show them in diagram. (5)

(b) Is $^2D_{1/2}$ a possible term? Calculate the angle between vector I and vector s in the $^2P_{3/2}$ state of a one electron atom. (5)

(c) What is space quantization? Calculate the possible orientations of the total angular momentum vector J corresponding to j=3/2 with respect to a magnetic field along the z axis. (5)

Useful integral

$$\int_{-\infty}^{+\infty} dx\, exp(-\alpha x^2 + \beta x) = \sqrt{\frac{\pi}{\alpha}} \exp(\beta^2 / 4\alpha)$$

$$\int_{0}^{+\infty} dx x^n\, exp(-\alpha x) = \frac{n!}{\alpha^{n+1}}$$