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SL No of QP	:	**5755**
Name of the Department	:	Physics
Name of the Course	:	B.Sc. Hons.–(Physics)_NEP: UGCF-2022
Name of the Paper	:	Mathematical Physics-I
Semester	:	I
Unique Paper Code	:	2222011101
Question Paper Set No	:	1

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 total.
3. Question No. **1** is compulsory.
4. **All** questions carry equal marks.

[6x3 = 18]

Q1. Answer any six of the following:

(a) A temperature field in a room is given by $T_{(x,y,z)} = 20 - x^2 - 2y^2 - z^2$ (in °C). Find the direction of maximum temperature increase at the point (1, -1, 2). What is the rate of increase in that direction?

(b) Expand the function $f(x) = \ln(1 + x)$ about x=0 up to the 4th order. Approximate $f(x = 0.5)$.

(c) Solve: $(2y^3 + 2)\,dx + 3xy^2dy = 0$

(d) Find $\iint \vec{F}.\hat{n}\; dS$ for the vector field $\vec{F}_{(x,y,z)} = z\,\hat{\imath} + y\,\hat{\jmath} + x\,\hat{k}$, over the unit sphere $x^2 + y^2 + z^2 = 1$.

(e) Given the vectors $\vec{a} = (3,4)$ and $\vec{b} = (5,-2)$, compute their dot product before and after rotating the axes counterclockwise by 45°, and verify invariance.

(f) Find the Wronskian of the set $\{\sin x, 2\cos x, 3\sin x + \cos x\}$, and determine whether the set is linearly dependent or independent.

(g) From the probability distribution

X:	1	2	3	4	5
P(X):	k	2k	3k	2k	k

Find the value of k, and evaluate E(X).

Q2. (a) Using index notation δ_{ij} and ε_{ijk}, prove that $\vec{a}\; X\; (\vec{b}\; X\; \vec{c}) = (\vec{a}.\vec{c})\vec{b} - (\vec{a}.\vec{b})\vec{c}$ **8**

(b) If $\vec{A}$ is an irrotational vector field, show that $\vec{A} X \vec{r}$ is solenoidal, where $\vec{r} = x\hat{\imath} + y\hat{\jmath} + z\hat{k}$. **5**

(c) Evaluate: $\nabla.(r^3\vec{r})$ **5**

Q3. (a) Solve by the Method of Variation of Parameters: **9**

$$\frac{d^2y}{dx^2} - 3\frac{dy}{dx} + 2y = \frac{1}{(1+e^{-x})}$$

(b) Solve the differential equation: **9**

$$x^2\frac{d^2y}{dx^2} - 2x\frac{dy}{dx} + 2y = x^3 log\, x^2, \ \ (x > 0)$$

Q4. (a) Solve by Method of Undetermined Coefficients: **9**

$$\frac{d^2y}{dx^2} + 4y = 2\sin x\cos x - 7$$

(b) A resistor of $R = 2000\,\Omega$ and a capacitor of capacitance $C = 5\times10^{-6}\,F$ are connected in series to a 100 Volts DC source. What is the current $I(t)$ as a function of time for this RC charging circuit, given that $I = 10^{-2}\,A$ at the time the switch is closed $(t = 0)$. Also, determine the initial charge on the capacitor at $t = 0$. **9**

Q5. (a) Verify Green's theorem in the plane for $\oint_c (xy + y^2)\,dx + x^2\,dy$ where c is the closed curve of the region bounded by $y = x$ and $y = x^2$. **9**

(b) Consider the scalar function $T(x, y, z) = z^2$ defined on the tetrahedral domain enclosed by the three coordinate planes and the plane $x + y + z = 1$. The vertices of this tetrahedron are (0,0,0), (1,0,0), (0,1,0), and (0,0,1). Compute the volume integral of T over this region. **9**

Q6. (a) Obtain the expression for the mean and variance of the Binomial distribution. **8**

(b) In a radioactive decay process, the number of decays per minute is Poisson-distributed with a mean of 4. Find the probability that exactly 3 decays occur in one minute. **5**

(c) Find the scalar potential function ϕ for $\vec{F} = y^2\hat{\imath} + 2xy\,\hat{\jmath} - z^2\hat{k}$. **5**

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Name of the Department : **Department of Physics and Astrophysics**
Name of Course : **B.Sc. (H) Physics NEP**
Name of the Paper : **Wave and Oscillations (DSC 3)**
Semester : **I**
Unique Paper Code : **2222011103**

Duration: 2 hours **Maximum Marks: 60**

Write your roll no. on the top immediately on receipt of this question paper.

Attempt four (4) questions in all, including Question No. 1 which is compulsory.

(Symbols have their usual meanings.). Use of non-programmable calculator is allowed.

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

(a) Six simple harmonic oscillations each of same frequency and equal amplitude are superposed. The phase difference ϕ between any two consecutive oscillations is constant. If the resultant amplitude of the superposition is zero, what is the phase difference ϕ?

(b) Two tuning forks with natural frequencies γ_1 and γ_2, are struck at the same time with equal force. The intensity of the resulting sound beats with a frequency of 1 Hz. If the average frequency is 512 Hz, determine γ_1 and γ_2.

(c) The oscillations of a tuning fork of frequency 400 cps wane away to 1/e times its amplitude in 2 second. Calculate its damped frequency.

(d) Explain the transient state behavior of a system under forced oscillations.

(e) The string of a violin is to be tuned to a frequency of 640 Hz. Its length and mass (from the bridge to the end) are 33 cm and 0.125 g respectively. What tension is required?

(f) What are stationary waves? Why are they called so?

2) (a) A particle is subjected to two simple harmonic motions at right angle to each other, of equal amplitudes A, equal frequencies ω and a constant initial phase difference $\pi/2$. Derive an analytical expression for the resultant oscillation of the particle. Sketch the trajectory for the resultant oscillation.

(b) Two tuning forks A and B are used in an optical experiment to produce Lissajous figures. Frequency of fork A is 288 Hz. It is found that the sequence of figures repeats every 20 seconds. When fork B is loaded with a little wax, the time taken for sequence of the figures is found to repeat every 10 seconds. Determine the original frequency of fork B.

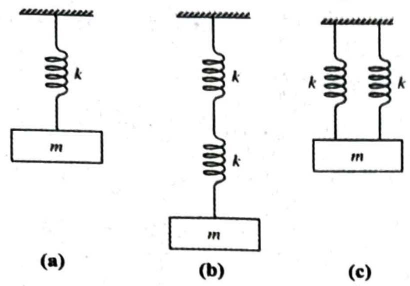
(c) Show that time period of a compound pendulum is minimum when points of suspension and oscillation are equidistant from its center of gravity. **(7, 4, 4)**

3) (a) A particle is subjected to N simple harmonic motions of same frequency. If the amplitude of each oscillation is A_o and ϕ is the phase difference between successive oscillations, show that the amplitude of the resultant oscillation is given by

$$A = A_o \sin\left(\frac{N\phi}{2}\right) / \sin(\phi/2)$$

(b) A uniform spring of force constant k is cut into two pieces whose lengths are in the ratio 1:3. Calculate the force constant of each piece.

(c) Show that the values of T, the period of three simple harmonic motions (a), (b) and (c) in the figure are in the ratio $1:\sqrt{2}:\frac{1}{\sqrt{2}}$. All springs are identical, each of spring constant k and of mass that is negligible compared to mass m.



(6, 4, 5)

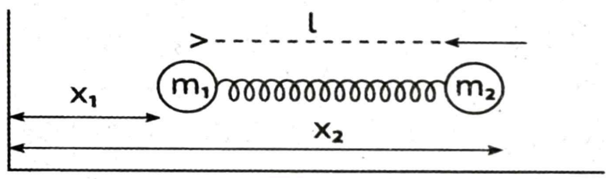
4) (a) Discuss the effect of damping on oscillatory motion. Write down the equation of motion for damped harmonic oscillator and solve it. Show that for heavily and critically damped cases, there is no oscillatory motion.

(b) Find the logarithmic decrement of a damped harmonic oscillator which has an initial amplitude of 20 cm and which reduces to 2 cm after 100 complete oscillations each of period 2.3 seconds. Also find the relaxation time.

(10, 5)

5) (a) Deduce the normal modes of transverse oscillations of N coupled oscillators. Obtain the expressions of amplitude for all N particles and permitted frequencies of the normal modes.

(b) In the figure below, two masses m_1 and m_2 are coupled by a spring of stiffness s and natural length l.



If x is the extension of the spring, then obtain the equation of motion along the x axis. Also show that the frequency of the system is given by $\omega^2 = \frac{s}{\mu}$ where μ is the reduced mass.

(10, 5)

(3)

[This question paper contains 4 printed pages.]

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

Sr. No. of Question Paper : 5735 **K**

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. **All** questions carry equal marks.

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

4. Attempt **four** more questions from the rest.

5. Simple Calculator may be allowed to use.

P.T.O.

1. Attempt any **six** questions from the followings : (6×3=18)

(a) Obtain cube roots of the given complex number $z = -1 + i$ and locate them graphically.

(b) Evaluate $(1+\sqrt{3}i)^{15}$.

(c) If a function $f(z) = u(x, y) + iv(x, y)$ is analytic then show that $|\nabla u| = |\nabla v|$ must hold.

(d) Find the real constants a and b such that the given function $f(z) = 3x - y + 5 + i(ax + by - 3)$ is 'analytic'.

(e) Find the Fourier transform of the function $f(t) = \delta(t)$.

(f) Show that the Fourier transform

$$\mathcal{F}\{f(at)\} = \frac{1}{|a|}F\left(\frac{\alpha}{a}\right)$$

where a is a constant and $\mathcal{F}\{f(t)\} = F(\alpha)$.

(g) Show that $\phi(x, y, z) = (x^2 + y^2 + z^2)^{1/2}$ satisfies the Laplace's equation in 3-dimensions.

2. (a) Solve $z^5 - 1 = 0$. (6)

Hence, prove that $1 + \cos 72^\circ + \cos 144^\circ + \cos 216^\circ + \cos 288^\circ = 0$.

(b) Show that the function (6)

$$f(z) = \sqrt{|xy|}$$

is not regular at the origin although the Cauchy-Riemann Conditions are satisfied at that point.

(c) Expand the function (6)

$$f(z) = \ln\left(\frac{1+z}{1-z}\right)$$

in Taylor series about z = 0 and hence find the 'radius of convergence' of f(z).

3. (a) Show that (9)

$$v(x,y) = \frac{x}{x^2+y^2}$$

is harmonic in domain D not containing the origin. Find the function f(z) = u(x,y) + iv(x,y) that is analytic in the domain D. Also express the function f(z) in terms of z. (9)

(b) Find the Fourier Integral transform of the function

$$f(x) = \begin{cases} 1 & |x| \leq a \\ 0 & |x| > a \end{cases}.$$

Plot f(x) and its Fourier transform F(α) for a = 3. (9)

4. (a) Using the concept of 'residue', evaluate the integral (10)

$\oint_C \frac{1}{z^4+1}\, dz,$ where C encloses all the singularities.

(b) Find the Fourier transform of the Gaussian distribution function (8)

$f(t) = e^{-at^2}$, with $-\infty < t < \infty$ & $a > 0$.

5. (a) Using Contour integration, evaluate (9)

$$\int_0^{2\pi} \frac{\cos 3\theta}{5 - 4\cos\theta}\, d\theta$$

(b) Using Contour integration, evaluate (9)

$$\int_0^{\infty} \frac{\cos x}{(x^2+a^2)(x^2+b^2)}\, dx.$$

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

$$3\frac{\partial u}{dx} + 2\frac{\partial u}{dy} = 0, \quad \text{with} \quad u(x,0) = 4\, e^{-x}.$$

(6)

(b) Solve the one-dimensional time dependent heat diffusion equation to find the temperature distribution u(x, t) in a bar of length L with the following boundary and initial conditions: (12)

$$u(0,t) = u(L,t) = 0, \ \forall\ t > 0$$
$$u(x,0) = F(x) \quad \forall \quad 0 < x < L.$$

(2000)

(4)

[This question paper contains 2 printed pages.]

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

Sr. No. of Question Paper	:	5813 K
Unique Paper Code	:	2222012302
Name of the Paper	:	Thermal Physics
Name of the Course	:	B.Sc. Hons.– (Physics)_NEP: UGCF-2022
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. Question no. **1** is compulsory. Attempt any **five** questions including Question no. **1**. **All** questions carry equal marks. (Use of non-programmable scientific calculator is allowed)

Q 1. Attempt any six questions. (3x6)

a) Explain what you understand by the adiabatic lapse rate.

b) If the door of a refrigerator is kept open for a long time, will it make the room cooler or warmer? Support your answer.

c) Determine the change in entropy when a mole of an ideal gas undergoes free expansion in which its volume changes to four times the original volume.

d) What is Gibb's free energy? Give its significance.

e) Prove that $U = F - T\left(\frac{\partial F}{\partial T}\right)_V$; where all symbols have their usual meanings.

f) Show that the mean energy of a Maxwellian gas molecule is three times its most probable energy.

g) Calculate the critical temperature of helium if the critical pressure is 2.26 atm and critical density is 69 kg m^{-3}.

h) Explain whether the free adiabatic expansion of a perfect gas leads to cooling or heating. Justify your answer.

Q 2. a) State first law of thermodynamics. Give the significance and limitation of the law. (5)

b) Derive a relation between the pressure and volume of a perfect gas undergoing an adiabatic change of state. Show that the adiabatic elasticity of a perfect gas is γ times its isothermal elasticity. (9)

c) Prove that $dH = C_P dT + V(1-\beta T)dP$; where β is the volume expansivity and other symbols have their usual meanings. (4)

Q 3. a) State and prove Carnot's theorem. (6)

b) Define thermodynamic scale of temperature. Show how it is identical with the perfect gas temperature. Explain why negative temperature is not possible on this scale. (6)

c) A reversible heat engine converts one-sixth of the input heat into work. When the temperature of the sink is reduced by 62°C, its efficiency is doubled, calculate the temperature of the source and the sink. (6)

Q 4. a) Explain Clausius statement of the second law of thermodynamics. Obtain the expression of the change in entropy in terms of the heat flow during an irreversible process. (8)

b) Will the entropy increase or decrease when 50 g of water at 0°C is mixed with 100 g of water at 80°C? Determine the change in the entropy. (4)

c) Describe how a magnetic substance is cooled to very low temperature by adiabatic demagnetization. (6)

Q 5. a) Describe how the second order phase transition is different from the first order phase transition. Give a reason why the Clausius Clapeyron equation fails at the transition point. Hence derive the Ehrenfest equation. (8)

b) Using Maxwell's relation, prove

i. $TdS = C_P dT - \boldsymbol{TV\beta dP}$ and (7)

ii. $\gamma - 1 = \frac{TV\beta^2}{\kappa_T C_V}$; where β is the volume expansivity and κ_T is the isothermal compressibility and other symbols have their usual meanings.

c) A substance on melting increases its specific volume by 0.150 $cm^3\ g^{-1}$. Determine the change in the melting point if the pressure is increased by two atmospheres. Given: Melting point of the substance = 80°C and its latent heat of fusion = 36 $cal\ g^{-1}$. (3)

Q 6. a) Derive an expression for the mean free path and discuss its dependence on temperature and pressure. (9)

b) Deduce the expressions for average velocity, root mean square velocity and most probable velocity of a gas molecule in terms of temperature (T) and Boltzmann constant (k_B) using the Maxwell Boltzmann Law of distribution of molecular velocities. (9)

Q 7. a) Describe the Joule-Thomson porous-plug experiment and discuss the results. Hence obtain the expression for Joule-Thomson coefficient. (12)

b) 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 x 10^{-2} Nm^4mol^{-2}, b=5.28 x 10^{-5} m^3mol^{-1} (C_P = 36.57 $Jmol^{-1}K^{-1}$ and R = 8.31 $Jmol^{-1}K^{-1}$). (6)

(1500)

Your Roll No.: ....

Serial No of Question Paper	:	**5970**
Name of the Department	:	Physics
Unique Paper Code	:	2222012303
Name of the Paper	:	Light and Matter
Name of the Course	:	B.Sc. Hons. – (Physics) NEP: UGCF – 2022
Semester	:	III
Maximum Marks	:	60

<u>Instructions for the candidates:</u>

1. Attempt only FOUR (4) questions.
2. Question No. 1 is compulsory.
3. Use of non-programmable scientific calculators is allowed.

1. Attempt any **<u>five</u>** questions (5x3=15)

a) In Llyod's single mirror interference experiment, the slit source is 5mm from the plane of the mirror. The screen is kept 2.5m from the source. Calculate the fringe width if the wavelength of the incident light is 500nm.

b) Explain why fringe width decreases as we move away from center in outward direction in Newton's rings.

c) The distance between two consecutive bright bands in Young's experiment is 0.32 mm when the red light of wavelength 6400 Å is used. By how much will this distance change if the light is substituted by the blue light of wavelength 4800 Å with the same setting?

d) Sodium light of wavelength $\lambda = 5890$ Å is incident on a wedge-shaped air film. When viewed normally 10 fringes are observed at the distance of 1 cm. Calculate the angle of the wedge.

e) For a crystal with interplanar spacing $d = 2.50$ A° and X-rays of wavelength 1.25 A° determine the maximum possible order of diffraction.

f) How is phase velocity of a wave packet associated with matter waves, related to group velocity and particle velocity?

2(a) Why do we require to associate a wave packet with a matter particle? Which physical phenomena or law would be violated if a single wave is associated with a matter particle? Considering a one dimensional wave packet, bring out the dependence of group velocity on wave number k. (7)

(b) Bring out the similarity and differences in behaviour of light and matter waves while interacting with matter vis a vis Photoelectric effect and Compton effect in not more than 5 points. (5)

(c) Compute the group velocity and phase velocity of a proton whose de Broglie wavelength is 2m and 1×10^{-10} m. Given the mass of proton is 1.67×10^{-27} Kg, and $h = 6.624 \times 10^{-34}$ Js. (3)

3(a) State the Rayleigh's criterion of resolution. Determine the chromatic resolving power of a grating with N number of spacing. (5)

(b) Explain how interference fringes are formed by a wedge-shaped film when examined by reflected light. Find the expression for fringe width. (7)

(c) A drop of oil of volume 0.2cc is dropped on the surface of a tank water of area1sq.m. The oil film spreads uniformly over the whole surface. White light which is incident normally on the surface is observed through spectroscope. The spectrum is seen to contain one dark band whose center has wavelength 5500nm in air. Find the refractive index of oil. (3)

4(a) Giving necessary theory discuss the intensity distribution in Fresnel's diffraction due to a straight edge. (10)

(b) Prove that the area of a half period zone on a plane wavefront is independent of the order of the zone. (5)

5(a) Obtain the expression for intensity in Fraunhoffer diffraction due to a double slit. (7)

(b) Explain the missing orders if the separation between the two slits is three times the slit width. (3)

(c) In a plane transmission grating the angle of diffraction for the second order principal maxima for λ=5000 Å is 30°. Calculate the number of lines in one cm of the grating surface. (5)

(6)

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No of page. 2

Name of the Course : B.Sc. Hons Physics UGCF-NEP

Semester : III

Name of the Paper : Numerical Analysis (DSE)

Unique Paper Code : 2223012001

S. No. of Question Paper :

Duration: 2 hours **Maximum marks: 60**

Note:

i) Attempt four questions in all. Question no. 1 is compulsory.
ii) Non-programmable scientific calculators are allowed

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

(a) The error in the measurement of the area of a circle is not allowed to exceed 0.1%. How accurately should the diameter be measured?

(b) Find the eigenvalues of the matrix $\begin{bmatrix} 5 & 0 & 1 \\ 0 & -2 & 0 \\ 1 & 0 & 5 \end{bmatrix}$

(c) Given $A = \begin{bmatrix} 25 & 24 & 10 \\ 66 & 78 & 37 \\ 92 & -73 & -80 \end{bmatrix}$, show that A is an ill-conditioned matrix.

(d) Give a geometrical interpretation of the trapezoidal rule.

(e) State the minimax theorem.

(f) State Runge-Kutta fourth-order formula

2. (a) Solve the following equations by LU decomposition method.

$$2x_1 + x_2 + x_3 = 2$$

$$x_1 + 3x_2 + 2x_3 = 2$$

$$3x_1 + x_2 + 2x_3 = 2$$

(7)

(b) Solve by following equation by Gauss-Seidel method:

$$10x_1 + x_2 + x_3 = 12$$

$$2x_1 + 10x_2 + x_3 = 13$$

$$2x_1 + 2x_2 + 10x_3 = 14$$ **(8)**

3. (a)Find the largest eigen value and the corresponding eigen vector of the following matrix using power method taking $\begin{bmatrix}1\\0\\0\end{bmatrix}$ as the initial approximation for the eigen vector. (Compute Five iterations)

$$A = \begin{bmatrix}1 & 6 & 1\\1 & 2 & 0\\0 & 0 & 3\end{bmatrix}$$ **(8)**

(b) Solve the following equations using the Gauss elimination method

$$x_1 + x_2 + x_3 = 6$$

$$3x_1 + 3x_2 + 4x_3 = 20$$

$$2x_1 + x_2 + 3x_3 = 13$$ **(7)**

4. (a) Using Newton's divided difference formula, calculate the value of f(6) from the following data:

x	1	2	7	8
f(x)	1	5	5	4

(8)

(b) The value of x and y are given as below:

x	5	6	9	11
y	12	13	14	16

Using Lagrange interpolation, find the value of y at x = 10 **(7)**

5. (a) Evaluate $\int_0^4 e^x\, dx$ using Simpson's $\frac{1}{3}$ rule taking step size h = 1 **(6)**

(b) Solve $\frac{dy}{dx} = -2xy^2$ with y(0)=1 and h=0.2 on the interval [0, 1], using Runge-Kutta fourth order method. **(9)**

(500)

(7)

[This question paper contains 4 printed pages.]

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

Sr. No. of Question Paper : 5716 **K**

Unique Paper Code : 2222013501

Name of the Paper : Electromagnetic Theory

Name of the Course : **B.Sc. (H) Physics_NEP-UGCF-2022**

Semester : V

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. Scientific (non-programmable) calculators are allowed.

P.T.O.

1. Attempt any **6** parts of the following : (6×3=18)

(i) Write Maxwell's equations in differential form and mention the physical significance of each term.

(ii) Define Coulomb and Lorentz gauges. What is the advantage of using Lorentz gauge in wave propagation problems?

(iii) What are the conditions for a crystal plate to act as a quarter-wave and a half-wave plate.

(iv) What is the difference between optical rotation and polarization rotation?

(v) What is an extraordinary ray? In which crystal does it occur?

(vi) A plane EM wave of frequency 1 GHz propagates in copper ($\sigma = 5.8\times10^{7}$ S/m, $\mu = \mu_0$). Find the skin depth.

(vii) The specific rotation of sugar solution is 66° dm^{-1} $(g\ cm^{-3})^{-1}$. A 10 cm tube produces a rotation of 13°. Find the concentration of the solution.

2. (a) Derive Poynting's theorem and interpret each term. (10)

(b) Explain the concept of energy flow in electromagnetic fields using an example. (5)

(c) Sunlight incident on Earth delivers about 1.3 kW/m^2. Find the amplitude of the electric and magnetic fields associated with sunlight. (3)

3. (a) Starting from Maxwell's equations, derive the electromagnetic wave equation in free space. (8)

(b) Prove that electromagnetic waves in vacuum are transverse in nature. (5)

(c) An EM wave has $E = 100 \cos(2\pi \times 10^8 t - \beta z)$ V/m in a medium with $\varepsilon = 4\varepsilon_0$, $\mu = \mu_0$. Find the wave velocity and intrinsic impedance. (5)

4. (a) State and derive Fresnel's formulae for perpendicular polarization. (10)

(b) Explain Brewster's angle and show how it can be used for polarization. (5)

(c) For a light beam passing from air to glass (n = 1.5), find the angle of incidence at which reflection vanishes. (3)

5. (a) Discuss the propagation of EM waves in an anisotropic medium and define dielectric tensor. (10)

(b) Distinguish between plane, circular, and elliptically polarized light with sketches. (5)

(c) A quartz plate of thickness 0.6 mm has refractive indices 1.553 and 1.544 for e- and o- rays respectively. For which wavelength will it act as a quarter-wave plate? (3)

6. (a) Derive the eigenvalue equation for TE modes in a planar dielectric waveguide. (12)

(b) Explain phase and group velocities in guided waves. (6)

Constants :

$\varepsilon_0 = 8.854 \times 10^{-12}$ F/m and $\mu_0 = 4\pi \times 10^{-7}$ H/m

Intrinsic impedance of free space: $\eta_0 \sim 377\ \Omega$

Speed of light $c = 1/\sqrt{\mu_0 \varepsilon_0} \approx 3 \times 10^8$ m/s.

(8)

Roll No..................

Sr. No. of Question paper	: **5794**
Unique Paper Code	: 2222013502
Name of the Paper	: Quantum Mechanics-I
Name of the Course	: B.Sc. Hons.– (Physics)_NEP: UGCF-2022
Semester	: V
Duration	: 3 hours
Maximum Marks	: 90 Marks

Instruction for Candidates

1. Write your roll number on the top immediately on receipt of this question paper.
2. Attempt a total of **5** questions. **All** questions carry equal marks.
3. Question No. **1 (One)** is compulsory.
4. Non programmable scientific calculators are allowed.

1. Attempt any six of the following questions: **($3 \times 6 = 18$ Marks)**

(a) An electron is bound in a finite square well of depth $V_0 = 10\ eV$ and width $a = 1\ nm$. Estimate whether at least one bound state exists.

(b) Verify the operator equation $x^2p - px^2 = 2i\hbar x$, where x, and p are position an momentum operators respectively.

(c) The wave function $\psi(x) = Ae^{-b^2x^2}$ is the ground state of one-dimensional harmonic oscillator. Here A and b are real constants. What are the units of "A" and "b".

(d) An atomic state of H-atom is represented by the following wave function : $\psi(r,\theta,\phi) = \frac{1}{\sqrt{2}}(\frac{1}{a_0})^{3/2}(1 - \frac{2}{2a_0})e^{-r/2a_0}\cos\theta$, where a_0 is constant. What are the values of the quantum numbers (n, l and m) associated with this state.

(e) The spherical harmonic is $Y_{11}(\theta,\phi) = -\sqrt{\frac{3}{8\pi}}\sin\theta e^{i\phi}$. Show that $Y_{11}(\theta,\phi)$ is the eigenstate of $\hat{L}_z$.

(f) Evaluate the commutator $[\hat{S}^2, \hat{S}_z]$ and explain physical significance of the result.

(g) Defining the ladder operators as $\hat{L}_\pm = \hat{L}_x \pm i\hat{L}_y$, show that $\hat{L}_+\hat{L}_- = \hat{L}^2 - \hat{L}_z^2 + \hbar L_z$

2. Answer the following

(a) Derive Ehrenfest's theorem starting from the time-dependent Schrodinger equation and show that quantum mechanical averages follow the form of classical equations of motion.

$$\frac{d\langle \hat{X} \rangle}{dt} = \frac{\langle \hat{P} \rangle}{m} \quad \text{and} \quad \frac{d\langle \hat{P} \rangle}{dt} = -\frac{\langle dV \rangle}{dx}.$$

Also discuss the physical significance of this result, showing how it connects quantum mechanics with classical Newtonian dynamics in the limit of expectation values.

12 Marks

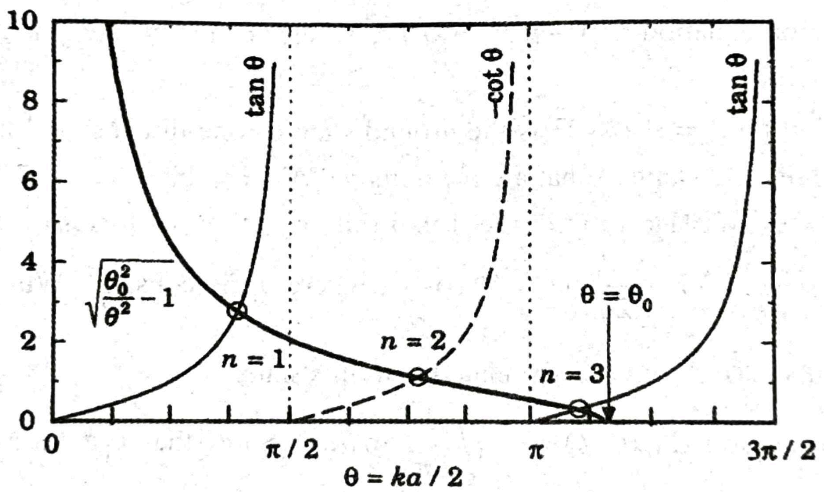
(b) An electron is trapped in a 1-D quantum well with finite depth whose width is a and potential energy barrier is V_0. The potential energy distribution is $V(x) = 0$ for $|x| \leq a/2$ and $V(x) = V_0$ for $|x| \geq a/2$. The possible wave number k is determined by the following two equations:

$$\tan(\theta) = \sqrt{\frac{\theta_0^2}{\theta^2} - 1} \quad \text{for } s\pi \leq \theta < (s + 1/2)\pi \ \ (s = 0,1,2,3.....)$$

Or

$$\cot(\theta) = \sqrt{\frac{\theta_0^2}{\theta^2} - 1} \quad \text{for } (s + 1/2)\pi \leq \theta < (s + 1)\pi \ \ (s = 0,1,2,3.....)$$

where $\theta = ka/2$, $\theta_0 = \dfrac{mV_0a^2}{2\hbar^2}$ and m is the mass of the electron. For a particular quantum well, solutions to the above equations can be determined using the diagram in figure below



Indicate how many possible trapping states for this electron. Estimate the energy of the electron at these states in terms of a, m and V_0. Compare the energies with those for an electron trapped in an infinitely deep quantum well with the same width a.

6 Marks

3. Answer the following

(a) Let ϕ_0 be the normalised ground state of the harmonica oscillator, $\hat{a}\phi_0 = 0$ and $\langle\phi_0|\phi_0\rangle = 1$, where $\hat{a}$ is the annihilation operator and $\hat{a}^\dagger$ is the creation operator. Given $[\hat{a}, \hat{a}^\dagger] = 1$

(i) Show that $\hat{a}\phi_n = \sqrt{n}\phi_{n-1}$ and $\hat{a}^\dagger\phi_n = \sqrt{n+1}\phi_{n+1}$.

(ii) Define the "number" operator $\hat{N} = \hat{a}^\dagger\hat{a}$. Show that $[\hat{N}, \hat{a}] = -\hat{a}$ and $[\hat{N}, \hat{a}^\dagger] = \hat{a}^\dagger$. What are the eigenfunctions of $\hat{N}$, and what are its eigenvalues?

(iii) Express $\hat{x}^2$ and $\hat{p}^2$ in terms of $\hat{a}$ and $\hat{a}^\dagger$. Use these expressions to show that when the harmonic oscillator is in an energy eigenstate $\psi = \phi_n$,

$$\Delta x \Delta p = \frac{\hbar}{2}(2n+1)$$

12 Marks

(b) The quantum state of harmonic oscillator has the eigenfunction :

$$\psi(x,t) = \frac{1}{\sqrt{2}}\phi_0(x)e^{-iE_0t/\hbar} + \frac{1}{\sqrt{3}}\phi_1(x)e^{-iE_1t/\hbar} + \frac{1}{\sqrt{6}}\phi_2(x)e^{-iE_2t/\hbar}$$

where $\phi_0(x), \phi_1(x)$ and $\phi_2(x)$ are real normalised eigenfunctions of the harmonic oscillator with energy E_0, E_1 and E_2 respectively. Find the expectation value of the energy.

6 Marks

4. Answer the following

(a) Write down the Schrodinger's equation in spherical polar coordinates. Starting from the radial part of the hydrogen atom Schrödinger equation

$$\frac{d^2U}{dr^2} + [\frac{2m}{\hbar^2}(E + \frac{e^2}{4\pi\epsilon_0 r} - \frac{l(l+1)}{r^2})]U = 0 \text{ , where } U(r) = rR(r)$$

Derive the solution $R(r)$ using the Frobenius method. Is this solution depends on the angular momentum (l), energy (E), and principal quantum number (n).

12 Marks

(b) The wave function for 1s state H-atom is given as

$$\psi_{100} = Ne^{-r/a_0}$$

(i) Calculate the expectation value of potential energy $\langle V(r)\rangle$ in this state and show that $E = \langle V(r)\rangle/2$, where E is the total energy.

(ii) Using the relation $E = T + V(r)$, evaluate the expectation value of kinetic energy $\langle T\rangle$ and show that $\langle T\rangle = -\langle V(r)\rangle/2$.

6 Marks

5. Answer the following

(a) Consider a H-atom whose state at a time $t = 0$ is given by

$$\psi(\vec{r},0) = A\phi_{200}(\vec{r}) + \frac{1}{\sqrt{5}}\phi_{311}(\vec{r}) + \frac{1}{\sqrt{3}}\phi_{422}(\vec{r})$$

(i) Find A so that the state is normalized.

(ii) Find the state of this atom at any later time t.

(iii) If a measurement of the energy were carried out, what values would be found and with what probabilities? Find the mean energy of the atom.

12 Marks

(b) What are Pauli spin matrices? Consider a particle with spin 1/2, show that $\hat{S}^2 = \frac{3}{4}\hbar^2 \hat{I}$

6 Marks

6. Answer the following

(a) Consider a particle in a normalized eigenstate of $\hat{L}^2$ and $\hat{L}_z$, $\psi \propto Y_{lm}$ and $\langle\psi|\psi\rangle = 1$. Show that in this case $\langle\hat{L}_x\rangle = \langle\hat{L}_y\rangle = 0$ and $\langle L_x^2\rangle = \langle L_y^2\rangle = \frac{\hbar^2}{2}[l(l+1) - m^2]$ and hence evaluate the uncertainty relation $\Delta L_x \Delta L_y \geq \frac{\hbar}{2}|\langle\hat{L}_z\rangle|$

12 Marks

(b) Evaluate the following commutator relations for the angular momentum operator

(i) $[\hat{L}^2, \hat{L}_z]$, where $\hat{L}^2 = \hat{L}_x^2 + \hat{L}_y^2 + \hat{L}_z^2$

(ii) $[\hat{S}_x, \hat{S}_+]$, where $\hat{S}_+ = \hat{S}_x + i\hat{S}_y$

6 Marks

Useful integrals:

$$\int_{-\infty}^{+\infty} dx e^{-\alpha x^2 + \beta x} = \sqrt{\frac{\pi}{\alpha}} e^{\beta^2/4\alpha} \qquad \int_0^{+\infty} dx x^n e^{-\alpha x} = \frac{n!}{\alpha^{n+1}}$$

(2)

[This question paper contains 02 printed pages.]

5851

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

Name of the Course	:	**B.Sc. Hons. – (Physics)_NEP_UGCF-2022**
Semester	:	**V**
Name of the Paper	:	**Digital Electronics**
Unique Paper Code	:	**2222013503**
S. No. of Question Paper	:	

Duration: **3 hours** Maximum marks: **90**

Instructions for Candidates

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

Attempt **five** questions in all.

Question No. **1** is compulsory.

All questions carry equal marks.

1. Attempt any **Six** parts (all parts carry equal marks) $(6 \times 3 = 18)$

(a) Show that NAND and NOR gates are universal gates.

(b) Explain scale of integrations: SSI, MSI, LSI and VLSI.

(c) Explain race around condition in JK Flip Flop. Write two ways by which race around condition may be prevented.

(d) Write excitation table for S-R Flip Flop.

(e) Describe Pin – Out diagram for IC 555.

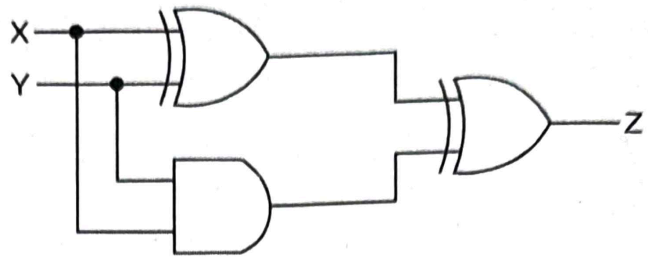
(f) Simplify, $Y = (A + B)(A'(B' + C'))' + A'(B + C)$

(g) Calculate the frequency and duty cycle of the 555 Astable Multivibrator output for $C = 0.01\ \mu F$, $R_A = 10\ k\Omega$, and $R_B = 50\ k\Omega$

2. (a) Minimize the following expressions using K-map: F(A, B, C, D) = $\sum m(4, 5, 7, 12, 14, 15) + \sum d(3, 8, 10)$

Design the logic circuit using basic gates. (10)

(b) Redraw the following circuit after simplification:



(8)

3. (a) Draw the circuit diagram for full adder using NAND Gates. Write its truth table. (8)

(b) Distinguish between a 4 – bit multiplexer and an encoder using appropriate diagrams. Using block diagram realize 8 × 1 multiplexer using two 4 × 1 multiplexers and a OR Gate and explain its functioning. (10)

4. (a) Draw the circuit diagram of Master – Slave JK Flip Flop using gates. Write its truth table. Explain its working. Explain how race around condition is prevented in this circuit. (10)

(b) Convert SR Flip flop to JK Flip Flop using excitation table. (8)

5. (a) Design Synchronous 3-bit Down-counter using JK Flip Flops. (10)

(b) Draw circuit diagram for 4 bit Parallel – in – Serial – out shift register. Explain its working. (8)

6. (a) Draw the circuit diagram of an Astable Multivibrator using IC555 and explain its operation. Derive an expression for frequency and duty cycle of the output waveform. Discuss the condition for 50% duty cycle. (12)

(b) What is the function of the control voltage (pin 5) in a 555 timer? (2)

(c) Explain the working of XOR gate as parity checker. (4)

(10)

5936

Unique Paper Code : 2223010014

Name of the Paper : Physics of Materials (DSE Paper)

Name of the Course : B.Sc. Hons.– (Physics)_NEP: UGCF-2022

Semester : V - Semester

Duration : 2 hours

Maximum Marks : 60 Marks

Instructions for Candidates

1. Attempt a total of four questions, including Question No. 1, which is compulsory.
2. Write your roll number on the top immediately on receipt of this question paper.

Q1. Attempt any five **(3 × 5=15)**

(a) How do electron mobility and hole mobility differ from each other?

(b) Define Fermi temperature and explain its physical meaning.

(c) How does density of states affect the carrier concentration in a semiconductor?

(d) Calculate the drift velocity of electrons in a material with mobility of $1000 cm^2/V \cdot s$ when an electric field of 50V/cm is applied.

(e) How does temperature affect grain size in ceramic materials?

(f) Discuss the importance of vacuum in the deposition of thin films by thermal evaporation and pulsed laser deposition?

Q2. (a) Explain how the structure and properties of conducting polymers influence their conduction mechanism. Evaluate their advantages and limitation in organic electronics. **(7)**

(b) Discuss the principles of operation of liquid crystal display devices, emphasizing the manipulation of light through electric fields. **(5)**

(c) Explain the importance of Fermi surface. **(3)**

Q3. (a) Illustrate and explain the band structure of graphene. Why is graphene considered a zero-gap semiconductor, and how does this relate to its exceptional conductivity? **(7)**

(b) Explain the Czochralski method of crystal growth. Discuss how controlling parameters such as pulling rate and temperature gradient influences crystal quality. **(8)**

Q4. (a) Classify magnetic materials into soft and hard magnets. Describe the structural and magnetic properties that distinguish these two categories. **(7)**

(b) In a pyroelectric detector, if charge sensitivity is $1.2\times10^{-9} C/K$ and the detector voltage is 5 V, calculate the capacitance of the device. **(5)**

(c) Explain the importance of spin transport in the development of next-generation memory and logic devices. (3)

Q5. (a) How is electron concentration in an n-type semiconductor determined? Derive the expression in terms of doping concentration and Fermi level. **(8)**

(b) For a given intrinsic semiconductor at 300 K with bandgap energy of 1.1 eV, calculate the intrinsic carrier concentration, assuming the effective density of states in conduction and valence bands are 2.8×10^{19} cm^{-3} and 1.04×10^{19} cm^{-3} respectively. **(7)**

(N)

This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **10905**

Unique Paper Code : **2223010036**

Name of the Paper : **DSE–Nuclear and Particle Detectors**

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

Semester : **VII**

Duration : **3 Hours** Maximum Marks : **90**

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

Attempt *five* questions in all.

Question No. **1** is compulsory.

Each question carries **18** marks.

Use of scientific calculator is allowed.

1. Attempt any *six* parts from the following : 6×3 = 18

 (*a*) Differentiate between mass and linear attenuation coefficients.

 (*b*) "The pulse height in an ionization chamber is proportional to the energy deposited". Justify the statement.

 (*c*) A GM tube has dead time $\tau = 300$ μs. Observed $rate = 2500\ counts/s$. Compute the true count rate.

 (*d*) Differentiate between absolute efficiency and intrinsic efficiency of a radiation detector.

(*e*) How can a single channel analyzer be used to measure energy spectra ?

(*f*) How is stopping power of a material related to the range and energy of an incident ionising radiation ?

(*g*) What is the basic working principle of Computed Tomography.

2. (*a*) Discuss any three of following interactions with the help of appropriate equations and examples : 6

   (*i*) Elastic Scattering

   (*ii*) Inelastic Scattering

   (*iii*) Radioactive Capture

   (*iv*) Transmutation

   (*v*) Spallation reactions.

   (*b*) (*i*) Define the term "Bremsstrahlung" radiation. How does it differ from characteristic radiation ?

   (*ii*) In an X-ray machine, electrons are accelerated through a potential of 40 kV. Compute the cut-off wavelength and energy of the emitted photons. 3+3

   (*c*) Explain the Compton scattering mode of photon interaction with matter. A photon incident on an atom scatters off at an angle of 55° with an energy of 150 keV.

   Determine the initial energy of the photon and the energy of the scattered electron. (Cos 55° = 0.5736 and Sin 55° = 0.8191). 3+3

3. (*a*) Assume radiations of two different energies are incident on a gas detector, with the help of a diagram explain its response with increase in the bias voltage. 6

(b) Define *dead time* of a detector. Illustrate with the help of a diagram, the effect of dead time on the count rate in a system. 2+4

(c) A typical gas filled detector has a capacitance of about 50 μF and charge collection time of the order of 1 μs. If all the charge created by a 3 MeV particle is assumed to be collected then estimate the expected voltage and current output. 6

4. (a) How does a multiwire proportional counter (MWPC) detect and locate the position of incident nuclear radiation ? 6

(b) Explain the mechanism of conversion of ionising radiation energy into detectable light signals by an organic scintillator detector. (Use a molecular energy-level diagram). 6

(c) A germanium detector is illuminated by a ^{57}Co source producing E = 122 keV photons. Calculate :

(i) the mean number of electron–hole pairs produced.

(ii) variance in number of pairs using the Fano factor.

(iii) percentage energy resolution.

Given for Ge: average energy to produce one electron–hole pair, $w = 2.96\ eV$ and Fano factor, F = 0.13 2+2+2

5. (a) Using the schematic diagram of a photomultiplier tube, explain the role of the dynode ladder and photocathode in its working. 6

(b) Explain how the $Li(n, \alpha)$ reaction is used for detecting slow neutrons. 6

(c) A material having a work function of 2 eV is used to convert photons into electrons, which are then detected by a photomultiplier tube. Compute the maximum wavelength of the photons it can convert into electrons. 6

6. (*a*) What is NIM logic ? Explain the necessity of terminating fast NIM logic signals with a matched 50 Ω impedance at the receiving end. 2+4

(*b*) How does a timing filter amplifier process a nuclear pulse ? 6

(c) What are the shortcomings of a voltage-sensitive preamplifier ? How can they be avoided by using a charge-sensitive preamplifier ? 2+4

7. (*a*) Explain the basic principle of working of Magnetic Resonance Imaging. Discuss the role of the external magnetic field and radio frequency pulses in producing MRI signals. 3+5

(*b*) Hydrogen (^1H) is the most commonly used nucleus in MRI. What property of hydrogen nuclei makes them particularly suitable for imaging soft tissues ? 4

(c) A proton has a gyromagnetic ratio, $\gamma = 2.68 \times 10^8\ rad \cdot s^{-1}T^{-1}$. If an MRI scanner operates at a magnetic field, $B_o = 1.5\ T$, calculate the Larmor precession frequency (in MHz) of the proton. 6

(12)

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AB-18 - 62

Unique Paper Code: 2222511101 7110

Name of the Paper: Mechanics

Name of the Course: B.Sc. Prog.

Semester: I

Duration: 2 hours

Maximum Marks: Marks 60

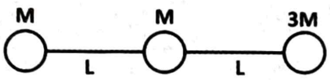
Instructions for Candidates

1. Write your Roll no. on the top immediately on receipt of this question paper.
2. Attempt **Four** questions in all.
3. Question number **one** is **Compulsory**

1.Attempt any **five :** **(5X3=15)**

a) Find a vector whose magnitude is same as that of $\vec{a} = 5\hat{\imath} + 12\hat{\jmath}$, and it is parallel to $\vec{r} = 8\hat{\imath} + 15\hat{\jmath}$.

b) Where is the centre of mass for the collection of masses shown below?



c) Is the Force $\vec{F} = (2xy + z^2)\hat{\imath} + x^2\hat{\jmath} + 2xz\,\hat{k}$ conservative?

d) Distinguish between polar vectors and axial vectors with examples.

e) Define Moment of Inertia. Give its physical significance.

f) A rod 1m long is moving along its length with a velocity 0.6 c. Calculate its length as it appears to an observer on Earth.

2 (a) If position vector is $\vec{r} = x\hat{\imath} + y\hat{\jmath} + z\hat{k}$, calculate gradient of $\frac{1}{r}$. (3)

(b) Solve the following differential equation $y'' + y' - 4y = 0$, y (x=0) = 1 and y (x =∞) = 0. (5)

(c) Solve: $D^2 - 6D + 8 = (e^{2x} - 1)^2$ (7)

3(a) Distinguish between elastic and inelastic collision. Show that in case of inelastic collision kinetic energy is not conserved. (5)

(b) A vessel at rest explodes, breaking into three pieces. Two pieces, having equal masses, fly off perpendicular to one another with the same speed of 30 m/sec. The third piece has three times the mass of each other piece. What is the direction and magnitude of its velocity immediately after the explosion? (5)

(c) Find the moment of inertia of a thin uniform rod about an axis passing through one end and perpendicular to its length. (5)

4 (a) Derive the differential equation for a damped harmonic oscillator. Obtain its general solution. Explain the physical significance of the overdamped and underdamped cases. (10)

(b) Find the equation of motion for simple pendulum and derive it time period. (5)

Q5 (a) What are Galilean Transformations? Show that the laws of Conservation of momentum are invariant to Galilean Transformation equations. (5)

(b) Derive the expression for the length contraction in relativity. (5)

(c) Two space crafts A and B are moving away from earth in the same direction with speed 0.8 c and 0.6 c respectively. Find the velocity of B with respect to A. (5)

(1000)

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[This question paper contains 2 printed pages.]

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

Semester: III

Name of the Paper: Heat and Thermodynamics

Unique Paper Code: 2222512301

Duration: 2 Hours

Maximum Marks: 60

Instructions for candidates

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

Q1. Attempt any ***five*** from the following: (5x3=15)

(a) Derive an expression for work done by an ideal gas during an isothermal expansion process.

(b) Using first law of thermodynamics, prove:

$$\frac{E_S}{E_T} = \frac{C_P}{C_V} = \gamma$$

where E_S & E_T are adiabatic and isothermal elasticity respectively.

(c) An investor claims to have developed an engine working between 500 K and 250 K with efficiency 54%. Is his claim valid? Justify.

(d) The average kinetic energy of a gas molecule at certain temperature is 6.21×10^{-21} J. Find the temperature.

(e) From Wien's displacement law calculate the temperature of sun, given that λ_m = 4753 Å and Wien's constant b = 0.2898×10^{-2} m-K.

(f) Define microstate and macrostate for a thermodynamical system.

Q2. (a) Using first law of thermodynamics, prove

$$C_P - C_V = \left[\left(\frac{\partial U}{\partial V}\right)_T + P\right]\left(\frac{\partial V}{\partial T}\right)_P$$

Hence show that for 1 mole of an ideal gas

$$C_P - C_V = R.$$

(b) Derive the equation of state for an ideal gas undergoing an adiabatic process in terms of pressure and volume.

(c) Draw the PV diagram for a Carnot's Engine and explain. Calculate the net work done by a Carnot engine in one complete cycle. Also derive an expression for its efficiency. (4,4,7)

Q3. (a) Write the expressions for four thermodynamic potentials - Internal Energy (*U*), Helmholtz function (*F*), Enthalpy (*H*) and Gibb's function (*G*). Derive four Maxwell's thermodynamical relations using these thermodynamic potentials.

(b) Given W = (U- G)/T where G is Gibb's function and U the internal energy. Show that W is constant for an ideal gas undergoing an adiabatic process.

(c) 50 g of water at 0°C is mixed with an equal mass of water at 100°C. Calculate the resultant increase in entropy. Given: specific heat of water is 1 cal g^{-1} $°C^{-1}$. (9,3,3)

Q4. (a) Derive an expression for mean free path for molecules in a gas using zeroth order approximation.

(b) Using kinetic theory of gases, obtain an expression for viscosity η of a gas and discuss its variation with temperature and pressure.

(c) What do you understand by a black body? Calculate the energy radiated by a black body at a temperature of 200 K. Given Stefan's constant = 5.67x 10^{-8} $MT^{-3}K^{-4}$ in SI units. (4,6,5)

Q5. (a) Derive Plank's law of black body radiation.
(b) Compare the basic postulates of Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics.
(c) Deduce relationship between Entropy and thermodynamic probability. (6,4,5)

Values of Constants:

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

(3000)

(13)

[This question paper contains 4 printed pages.]

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

Sr. No. of Question Paper : 7052 **K**

Unique Paper Code : 2222513501

Name of the Paper : Element of Modern Physics

Name of the Course : B.Sc. Prog.– (Physics)_NEP: UGCF-2022

Semester : V

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. Question No. 1 is compulsory.

4. All questions carry equal marks.

5. Use of a non-programmable scientific calculator is allowed.

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

a) Prove that the de-Broglie wave packet associated with the moving body travels with the same velocity as the body.

b) What are the conditions that must be satisfied by a physically acceptable wave function?

c) What do you understand by the term "probability density of a particle"? Explain its physical significance?

d) An electron is bound by a potential which closely approaches an infinite square well of width 2.5×10^{-10} m. Calculate the lowest possible quantum energy the electron can have?

e) An X-ray tube operated at 30 kV emits a continuous X-ray spectrum. Calculate the value of the minimum wavelength of X-rays produced?

f) State three properties of nuclear forces.

2. a) What is Photoelectric effect? Give an account of Einstein's explanation of the Photoelectric effect and derive the Einstein's photoelectric equation. (2, 8)

b) If light of wavelength 2500 Å falls on Cs, what is the maximum velocity of the ejected photoelectrons? Given: the work function of Cs is 1.9 eV. (5)

3. (a) Using Schrodinger equation, find the solution of the one-dimensional motion of a particle trapped in a box of infinitely hard walls. Show that the energy of the particle varies as the square of a natural number and draw the first 3 energy states. (10)

(b) Calculate the expectation value of the position $< x>$ of a particle trapped in a one dimensional box. (5)

4. a) State Heisenberg's uncertainty principle and discuss gamma ray microscope thought experiment. (10)

b) If an electron makes a transition from n = 4 to n = 2, determine the wavelength of emitted radiation. (5)

5. a) Discuss the principle, construction, and theory of a cyclotron. (10)

b) In a cyclotron, the r.f. potential applied across the dees at 20 kV and a magnetic field of 1.1 tesla. Accelerated protons are extracted from the dees at a radius of 28 cm from the centre of the dees. Find the maximum energy acquired by protons? (5)

Constants:

$h = 6.626 \times 10^{-34}$ Js

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

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

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

$m_p = 1.67 \times 10^{-27}$kg = 1.00866u

$m_n = 1.67 \times 10^{-27}$ kg = 1.00728u

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