UNIVERSITY OF THE PUNJAB

M.A./M.Sc. Part – I Annual Examination – 2022

Roll No. ……………

Subject: Physics **Paper: I (Mathematical Methods of Physics)** **Time: 3 Hrs. Marks: 100**

NOTE: Attempt FIVE questions in all, selecting at least TWO questions from each section.

SECTION – I

Q1(a): State and prove Gauss' divergence theorem. [10]

(b): Verify the Gauss' divergence theorem for $\vec{F} = x^2\hat{\imath} + y^2\hat{\jmath} + z^2\hat{k}$ over the cube formed by $x = 0, 1$; $y = 0, 1$; $z = 0, 1$. [10]

Q2(a):Define a tensorial quantity. Give two examples of it. [5]

(b): Prove that $A_{pq} = \begin{pmatrix} x_2^2 & -x_1x_2 \\ -x_1x_2 & x_1^2 \end{pmatrix}$ are the components of a second rank tensor in 2D

[15]

Q3(a): Find the Fourier series of $f(x)$ given by if: $f(x) = \begin{matrix} -\pi, & -\pi < x < 0 \\ x, & 0 < x < \pi \end{matrix}$ [10]

(b) Find the Fourier transform of the function defined as: $f(t) = \begin{matrix} 1, & -a \le t \le a \\ 0, & otherwise \end{matrix}$ [10]

Q4(a): State and prove Cauchy's Residue theorem. [10]

(b): Evaluate $\int_0^{2\pi} \frac{4d\theta}{5+4sin\theta}$. [10]

Q5.Show that the Cauchy Riemann equations are satisfied for the function $(z) = \exp[-z^{-4}]$. [20]

SECTION – II

Q6(a):For the Eigen value problem $y'' + \lambda y = 0$ where $y(0) = 0, y(\pi) = 0$, obtain the set of Eigen functions and the corresponding Eigen values. [10]

(b): Find the Green's function solution for $G(x)'' + k^2G(x) = -\delta(x - x')$, $x \neq x'$ with boundary conditions $G(0, x') = G(1, x') = 0$. [10]

Q7(a):For the Bessel's functions, prove that $e^{\frac{-x(t-\frac{1}{t})}{2}} = \sum_{n=-\infty}^{n=+\infty} J_n(x)t^n$ [12]

(b): $\frac{d}{dx}[x^nJ_n(x)] = x^nJ_{n-1}(x)$ [8]

Q8(a): Write the formula of $Y_n^m(\theta, \phi)$ and then find (i) $Y_0^0(\theta, \phi)$ (ii) $Y_1^0(\theta, \phi)$. [5+5]

(b): Derive the Rodrigue's formula for the Legendre's polynomials $P_n(x) = \frac{1}{2^nn!}\frac{d^n(x^2-1)^n}{dx^n}$.

[10]

Q9(a): Using tensorial notations, prove that: $CurlCurl\overrightarrow{A} = GradDiv\overrightarrow{A} - \nabla^2\overrightarrow{A}$ [10]

(b): If $f(z)$ is analytic with derivative $f(z)'$ which is constant at all the points on a simple closed curve C, then $\oint_C f(z)dz = 0$. [10]

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Subject: Physics **Paper: II (Classical Mechanics)** **Time: 3 Hrs. Marks: 50**

NOTE: Attempt FOUR questions, selecting at least ONE question from each section. All Questions carry equal marks.

SECTION – I

Q.1. A particle of mass m moves on the surface of sphere of radius r under the central potential

$$V(r) = -\frac{k}{r}$$

and having kinetic energy

$$T = \frac{1}{2}m\left(\dot{r}^2 + r^2\dot{\theta}^2 + \dot{\phi}^2\right)$$

a) Write all possible Euler Lagrange equations and calculate its all generalized momenta

b) Derive the equation of motion for r and θ by using Euler Lagrange equations

c) Discuss the motion if object is confined to move in plane also write its Lagrangian and identify its generalized coordinated with possible generalized momenta 4+4.5+4= 12.5

Q.2. A particle moves in a force field described by

$$F(r) = -\frac{k}{r^2}exp\left(-\frac{r}{a}\right)$$

where k and a are positive.

a) Write the equations of motion and reduce them to the equivalent one-dimensional problem.

b) Use the effective potential to discuss the qualitative nature of the orbits for different values of the energy and the angular momentum.

c) Show that if the orbit is nearly circular, the apsides will advance approximately by $\frac{\pi\rho}{a}$ per revolution, where ρ is the radius of the circular orbit.

4+4+4.5= 12.5

Q.3 (a)For each of the mechanical systems described below, give a configuration space and the number of degrees of freedom of that configuration space also cons

(i) A spring pendulum
(ii) A spherical pendulum
(iii) A point mass sliding without friction on a rigid curved wire.

Also construct the Lagrangian for the systems (i) and (ii)

(b) Describe the types of constraints associated to above all mechanical systems and explain how we can reduce the spring pendulum to simple pendulum.

(c) Construct the equation of motion for spring pendulum oscillating under force of gravity with spring constant K and mass of object is m. 4.5+4+4= 12.5

Q.4 (a)Construct the Hamilton-Jacobi differential equation for the following mechanical systems

(i) An object of mass m moving about a fixed point on curved path (circular motion) under the central force with potential energy $-\frac{k}{r}$, here k is constant, at any time the polar coordinates of object are (r(t) , $\theta(t)$).

(ii) For simple pendulum

(b)Solve the Hamilton-Jacobi differential equation derived for the above system in Q.4 (i). 6+6.5= 12.5

Q.5 (a) Derive the Hamilton's equations from Hamilton's principle for a system given with Lagrangian and Hamiltonian also discuss the number of Degree of freedom of a system in Hamiltonian formalism and what kind of information we can obtain from a point on trajectory in phase space.

(b) Derive the equation of motion associated to spring mass system (oscillating on horizontal frictionless surface) and solve it by using the idea of canonical transformation provided with generating function

$$F_1(q,Q,t) = \frac{m}{2}wq^2 cotQ$$

with canonical transformed equations $p = \frac{\partial F_1}{\partial q}$ and $P = -\frac{\partial F_1}{\partial Q}$. 6+6.5= 12.5

Q.6 a) Define Liouville's theorem also show that the phase space volume of a canonical system is invariant under canonical transformations.

b) Apply the Liouville's theorem to spring mass system with total energy

$$E = \frac{p^2}{2m} + \frac{1}{2}kx^2$$

to show that the density of the system of points in phase space remains constant. 8+4.5= 12.5

Q.7 a) If there is Lagrangian of the form $L(q_i, \dot{q}_i, t)$ and assume that Hamilton's Principle holds with the zero variation at the end points, Hamiltonian $H(q_i, p_i, t)$ is connected to the Lagrangian through the transformation as

$$H(q_i, p, t) = \sum_{i=1}^{n} p_i\, \dot{q}_i - L(q_i, \dot{q}_i, t)$$

then find Hamilton's equations of motion.

b) Construct the equation of motion for the system by using Hamilton's equation with Lagrangian is

$$L = \frac{1}{2}m\dot{q}^2 - \frac{k}{2}q^2$$

here k is constant (first find Hamiltonian)

c) A double pendulum consists of two simple pendula, with one pendulum suspended from the bob of the other. The two pendula have equal lengths and have bobs of equal mass and if the two pendula are confined to move in the same plane, then identify number of generalized coordinates, number of degree of freedom and derive constraint equations also mention their types. 4+4.5+4= 12.5

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M.A./M.Sc. Part – I Annual Examination – 2022

Subject: Physics | Paper: III (Quantum Mechanics) | Time: 3 Hrs. Marks: 100

NOTE: Attempt any FIVE questions, selecting at least ONE question from each section. All Questions carry equal marks.

Section - I

Q.1. (a) Define

(i) Stationary ~~states~~

(ii) Hamiltonian operator

(iii) Projection operator

(iv) Momentum operator

(v) Skew hermition operator

(b) Show that hermition operators have real eigen values.

(c) State correspondence principle

Q.2. (a) Consider a matrix A, a ket IΨ> and a bra <ϕI, $\begin{pmatrix} 5 & 3+2i & 3i \\ -i & 3i & 8 \\ 1-i & 1 & 4 \end{pmatrix}$, $|\Psi>= \begin{pmatrix} 1+i \\ 3 \\ 2+3i \end{pmatrix}$,

$<\varphi| = (6 \quad -i \quad 5)$. Calculate $A|\Psi\rangle$, $\langle\varphi|A$, $\langle\varphi|A\Psi\rangle$

(b) State superposition principle with help of examples. (12+6)

Q.3. (a) Calculate expectation value of x-component of linear momentum of a particle in state

$|\Psi(x,t)\rangle = Ae^{\frac{-x^2}{a^2}}e^{-i\omega t}sinkx$

(b) Define expectation value. Obtain the rate of change of expectation value of an operator A. (12+8)

Section – II

Q.4. Solve schodinger wave equation for a step [potential. Discuss quantum behavior of a particlein step potential for case (E>V_0)

$$V(x) = \begin{Bmatrix} 0, & x<0 \\ V_0, & x\geq 0 \end{Bmatrix}$$

Also show that R+T=1 (20)

Q.5. (a) Calculate the eigen values of L^2 and L_z.

(b) Define pauli spin matrices. Show that $\sigma^2 = {\sigma_x}^2 + {\sigma^2}_y + {\sigma^2}_z = 3I$ (12+8)

Q.6. (a) What are distinguishable and indistinguishable particles? Calculate the eigen values of exchange operator. Show that it commutes with hamlitonian operator.

(b) Give a detail comparison of fermions and bosons. (10+10)

Section – III

Q.7. Define perturbation. Calculate eigen value and eigen function upto 1st order correction of a perturbed particle using time independent perturbation theory. (20)

Q.8. Determine ground stat energy of simple harmonic oscillator using variational method. (20)

Q.9. (a) State and prove generalized uncertainty principle.

(b) What do you mean by quantum mechanical tunneling? (15+5)

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M.A./M.Sc. Part – I Annual Examination – 2022

Roll No. ……………

Subject: Physics **Paper: IV (Solid State Physics-1)** **Time: 3 Hrs. Marks: 50**

NOTE: Attempt FOUR questions, selecting at least ONE question from each section. All Questions carry equal marks.

Section – I

Q. 1. What do you mean by structure factor of the crystal, find its expression for body centered cubic (BCC) and face centered cubic crystal (FCC). ***(12.5 Marks)***

Q. 2. (a) Considering solid as a continuous medium, define stress and strain. Derive expressions for stress and strain components and then explain how these are reduced to six components in each case. ***(6.5 Marks)***
(b) Define the elastic compliance and elastic stiffness constants with their respective units ***(06 Marks)***

Q. 3. (a) What do you mean by interplanar spacing in a crystal structure, find an expression for the interplanar spacing in orthogonal crystal systems. ***(8.5 Marks)***
(b) Sketch planes $(\underline{1}21)$, $(2\underline{3}4)$, (320) and $(13\underline{3})$ in a unit cell of cubic crystal. ***(04 Marks)***

Q. 4. Enlighten inert gas crystals and their properties. Derive an expression for equilibrium distance and cohesive energy. ***(12.5 Marks)***

Section – II

Q. 5. (a) Explain the heat capacity of solids on the basis of Einstein's model. Is it superior to Dulong-Petit heat capacity model? Justify your answer. ***(9.5 Marks)***
(b) Explain the term anharmonic crystal interactions. ***(03 Marks)***

Q. 6. Considering solid as a discrete periodic medium. Find the dispersion relation for diatomic crystal. Sketch the dispersion relation in the first Brillouin Zone and explain the physical nature of optical and acoustic branches. ***(12.5 Marks)***

Q. 7. Write notes on the following
(a) Fick's Law of diffusion in solids. ***(6.5 Marks)***
(b) Color centers. ***(06 Marks)***

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Roll No. ……………..

Subject: Physics **Paper: V (Electronics)** **Time: 3 Hrs. Marks: 100**

NOTE: Attempt FIVE questions, selecting at least ONE question from each section.

	Section I	
Q.1	**(a)** Draw the circuit of full wave (center tapped transformer) rectifier with single capacitor filter and find the expression for ripple factor and V_{dc} in it.	**10**
	(b) Determine the ripple factor for full wave rectifier at 50 Hz frequency having capacitor filter 2000 μF and load taking 500 mA 6 V_{dc} .	**6**
	(c) Why are h-parameters called hybrid parameters?	**4**
Q.2	**(a)** Draw the h-parameter equivalent circuit of Common-emitter amplifier and derive expression for voltage gain, current gain, input and output resistances.	**10**
	(b) In a Common emitter amplifier we use R = 5 KΩ with a transistor having h_{fe} = 40, h_{ie} = 800 Ω, h_{re} = negligible and h_{oe} = 9 x 10 $^{-6}$ mho. Calculate g_m, A_{ve}, A_{ie}, R_{ie}, R_{oe} and power gain in dB.	**10**
Q.3	**(a)** Draw the voltage feedback bias circuit and find the relation for collector current and stabilizing ratio.	**10**
	(b) Design voltage feedback bias circuit and find out the value of R_C, R_E, and s stabilizing ratio when I_C = 2.3 mA, V_{BE} = 0.5V, h_{fe} = 75, V_{CC} = 15V, I_B = 30 μA h_{FE} = 75, V_{CE} = 0.5V_{CC} and V_E = 0.1V_{CC}.	**10**
	Section II	
Q.4	**(a)** Why the gain of RC coupled amplifier reduces at high frequency.	**2**
	(b) Discuss the low frequency response of RC coupled amplifier and find the expression for $A_{v(low)}$ and phase angle θ.	**12**
	(c) A transistor has C_{be} = 100 pF, C_{bc} = 3 pF, h_{ie} = 850 Ω, h_{fe} = 60 and R_c = 5 KΩ, then find out its Miller input capacitance C_{ie}.	**6**
Q.5	**(a)** Explain the construction, draw the symbol and working of n-channe MOSFET in Depletion mode with the help of its characteristics.	**10**
	(b) Describe how pinch-off is obtained in an n-channel JFET.	**7**
	(c) Why JFET cannot work in enhancement mode.	**3**
Q.6	**(a)** Draw the circuit of current series feedback and find the relation for feedback factor β, voltage gain with feedback and input and output resistances.	**10**
	(b) For the current series feedback circuit R_E = 1.5 KΩ, R = 10 KΩ, h_{ie} = 2 KΩ, h_{fe} = 50 and h_{oe} = 10^{-4} mho. Find the β, gain, input and output resistances, without and with feedback.	**10**
	Section III	
Q.7	**(a)** Write the two conditions of sustained oscillation.	**3**
	(b) Draw the circuit, explain the working and find the expression for frequency in practical Colpitt oscillator.	**10**
	(c) In a Colpitt oscillator C_1 = C_2 = 150 pF and L = 75 μH. Find frequency.	**7**
Q.8	**(a)** How the Power Amplifiers are classified?	**5**
	(b) Prove that the efficiency of class A amplifier is nearly 50%.	**10**
	(c) A transformer is mounted on an 8 Ω speaker. The turns ratio is 12:1. What ac primary resistance will be present?	**5**
Q.9	Write a note on any **two** of the following. **(i)** The operational amplifier. **(ii)** Darlington compound transistor. **(iii)** Monostable multivibrator.	**10** **+** **10**