UNIVERSITY OF THE PUNJAB

Part-I A/2018
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics
PAPER: III (Quantum Mechanics)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 100

NOTE: Attempt any FIVE questions, At least ONE question from each section.

Section I

Q1. (a) Define a Quantum mechanical wave function. List the conditions a wave function must satisfy in order to solve Schrődinger equation.

(b). Define Hermitian operator. Show that eigen values of a Hermitian operator are always real.

(4+4+7)

Q2. (a).Derive equation of continuity for Schrődinger wave equation.

1. (b). Normalize the wave function $\Psi(x) = A\exp(ikx)$ and find the value of constant A, where $0 < x < 10$. Find the current density and probability density for the given wave function.

(10+10)

Q3. (a) For a one dimensional simple Harmonic oscillator

$$\begin{aligned}\hat{H} &= -\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + \frac{1}{2}m\omega^2 x^2, \\ \hat{a} &= \sqrt{\frac{m\omega}{2\hbar}}\left(x + \frac{ip}{m\omega}\right), \\ \hat{a}\dagger &= \sqrt{\frac{m\omega}{2\hbar}}\left(x - \frac{ip}{m\omega}\right),\end{aligned}$$

show that

$$\begin{aligned}[\hat{a}\dagger, \hat{a}] &= 1, \\ \hat{H} &= \left(\hat{a}\dagger\hat{a} + \frac{1}{2}\right)\hbar\omega\end{aligned}$$

(b) For a simple Harmonic oscillator, it is given that $\hat{N}\Psi_n = n\Psi_n$, where $\hat{N} = \hat{a}\dagger\hat{a}$ and $n = 0, 1, 2, \cdots$. Show that

$$\hat{a}\Psi_n = \sqrt{n}\Psi_{n-1}.$$

Assume that $(\Psi_n, \Psi_n) = 1$.

(10+10)

PTO

Section II

Q4. Solve the time independent Schrődinger wave equation for a one-dimensional potential step for the case when $0 < E > V_0$, where

$$V(x) = \begin{cases} 0, & \text{for } -\infty < x < 0, \\ V_0, & \text{for } 0 < x < \infty. \end{cases}$$

Also calculate the reflection and transmission coefficients R and T and show that $R + T = 1$.

(20)

Q5. (a). In case of orbital angular momentum operator, can $\hat{L}^2$ and $\hat{L}_z$ both be simulataneously measured? Explain the reason.

(b). Write the expression for $\hat{L}_z$ in spherical polar coordinates. Obtain the eigenvalues and eigenfunctions of $\hat{L}_z$

(6+14)

Q6. (a). Define the following terms

(i). Identical particles

(ii). Fermions and Bosons

(iii) Exchange operator

(iv) Exchange degeneracy

(b). Write down the matrix representation of operators $\hat{S}_x, \hat{S}_y, \hat{S}_z, \hat{S}^2$. Obtain the eigenvalues and eigenstates of $\hat{S}_x$.

(8+12)

Section III

Q7. Develop time dependent perturbation theory to obtain the transition amplitude T_{fi}.

(20)

Q8. Write down the general method of obtaining WKB wavefunction

(20)

Q9. (a). State and prove generalized uncertainty principle.

(b). Obtain equation of motion for an operator $A_H(t)$ in Heisenberg picture.

(12+8)

UNIVERSITY OF THE PUNJAB

Part-I A/2018
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics
PAPER: II (Classical Mechanics)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 50

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

SECTION-I

1. (a) If L is a Lagrangian of a system of n degrees of freedom satisfying Lagrange equation of motion, show by direct substitution that

$$L' = L + \frac{d}{dt}F(q_1, \cdots, q_n; t),$$

also satisfies the Lagrange's equation of motion where F is an arbitrary differentiable function of its argument.

(b) 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, find the Lagrange's equation of motion. Do not assume small angels.

(c) What are Lagrange multipliers? Use the method of Lagrange multiplier to derive the Lagrange equations of motion for nonholonomic constraints.(4+4+4.5)

2. (a) Obtain the Lagrange equation of the second kind

$$\frac{\partial L}{\partial t} - \frac{d}{dt}\left(L - \dot{q}_i \frac{\partial L}{\partial \dot{q}_i}\right) = 0,$$

also derive Beltrami's identity.

(b) A pendulum of mass m is attached to a massless cart. The cart is attached with a spring of spring constant k and moves along x-axis. Determine the configuration space and find the Lagrange's equations of motion.

(c) A particle of mass m is placed at the top of a smooth hemisphere of radius a. Find the constraint reaction of the hemisphere on the particle and if the particle is disturbed, at what height it leaves the hemisphere.

3. (a) Discuss the motion of a body of mass μ in a cenral force field with the Lagrangian

$$L = \frac{1}{2}\mu\left(\dot{r}^2 + r^2\dot{\theta}^2\right) - V(r)$$

Use the angular momentum l and total energy E (constants of motion), to derive the equation

$$\frac{d^2}{d\theta^2}\left(\frac{1}{r}\right) + \frac{1}{r} = -\frac{\mu r^2}{l^2} f\left(\frac{1}{r}\right)$$

where $f\left(\frac{1}{r}\right)$ is the force law.

(b) Find the force law for a central force field that allows a particle to move in a logarithmic spiral orbit given by

$$r = k\exp(\alpha\theta)$$

where k and α are constants. Also calculate the total energy of the orbit. (7.5+5).

P.T.O.

4. (a) Show that the equation of a curve for which surface area is minimum is a catenary

$$x = a\cosh\frac{y-b}{a}$$

where a and b are constants.

(b) A particle of mass m is constrained to move on the inside surface of a smooth cone of half angle α. The particle is subject to a gravitational force. Determine a set of generalized coordinates and determine the constraints, also find the Lagrange's equation.

(c) Show that the geodesic on the surface of a sphere is a segment of great circle.

(4+4+4.5)

SECTION-II

5. (a)Consider a one parameter family of transformations

$$q_i(t) \to Q_i(s,t) \qquad s \in \mathbb{R}$$

such that $Q_i(0,t) = q_i(t)$. Show that if the Lagrangian is invariant under this transformation, then there exists a conserved quantity.

(b) Define Poisson bracket and Lagrange brackets. Show that the Poisson brackets are invariant under the canonical transformation.

(c) If $[u_r, u_i]$ and $\{u_r, u_j\}$ are the Lagrange and Poisson brackets respectively, then show that

$$\sum_{r=1}^{2n} [u_r, u_i]\ \{u_r, u_j\} = \delta_{ij}.$$

(4+4+4.5)

6. (a) State Hamilton's principle of least action and use it to derive Euler-Lagrange equations of a dynamical system.

(b) Derive Hamilton's equations of motion by using Legendre transformation.

(c) Show that the path followed by a particle in sliding from one point to another in the absence of friction in the shotest time is a cycloid. (4+4+4.5)

7. (a) Show that the phase space volume of a canonical system is independent of time (Liouville's Theorem)

(b)Show that the transformation

$$P = q\cot p,$$
$$Q = \ln\left(\frac{\sin p}{q}\right),$$

is canonical and also show that the corresponding generating function is

$$F = e^{-Q}\left(1 - q^2 e^{2Q}\right)^{\frac{1}{2}} + q\sin^{-1}\left(qe^{Q}\right)$$

(c)The Lagrangian of a charged particle moving in an electromagnetic field is given by

$$L = \frac{1}{2}mv^2 - e\phi + e\mathbf{A}.\mathbf{v}$$

where ϕ is the electromagnetic sclar potential and $\mathbf{A}$ is the vector potential. Find the Hamiltonian and Hamilton's equations..(4+4+4.5)

UNIVERSITY OF THE PUNJAB

Part-I A/2018
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics
PAPER: IV (Solid State Physics-1)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 50

NOTE: Attempt any FOUR questions selecting at least ONE question from each section.

Section -1

Q.1 (a) Explain the crystal structure of Sodium chloride in detail. (5)

(b) Consider (hkl) plane in a crystal lattice, prove that the reciprocal lattice vector **G**= $h\mathbf{b}_1+k\mathbf{b}_2+l\mathbf{b}_3$ is perpendicular to this plane and the distance between two adjacent parallel planes of the lattice is $d_{hkl}= 2\pi/|G|$ (4.5+3)

Q.2 (a) What do you mean by the interplaner spacing in a crystal structure, find an expression for the interplaner spacing in orthogonal crystal systems. (6.5)

(b) Explain the Miller indices of planes, sketch planes $(1\ 2\ \bar{1})$, (2 3 4), (3 2 0), $(1\ \bar{3}\ 0)$ in a unit cell of cubic crystal. (2+1+1+1+1)

Q.3 In the quantum expression of the solid, define stress and strain and explain how nine strain components and nine stress components are defined and reduced to six components in each case.

(12.5)

Q.4 What do you mean by the structure factor of the crystal, find its expression, evaluate and explain it for FCC and BCC crystals. (12.5)

Section -11

Q.5 Derive the dispersion relation of phonons in a monoatomic crystal, sketch it in the first Brillouin zone and also discuss it under the long wavelength limit. (12.5)

Q.6 What do you mean by the heat capacity of solid, derive its expression in the Deby model.

(12.5)

Q.7 Write short notes on the following: (6.5+6)

i) Color Centres in solid

ii) The Diamond structure

UNIVERSITY OF THE PUNJAB

Part-I A/2018
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics
PAPER: I (Mathematical Methods of Physics)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 100

NOTE: Attempt FIVE questions, at least TWO questions should be selected from each section.

Section-I

- Q.No.1.
- a) A particle is moving in space . Find the expression for its velocity and acceleration in cylinderical coordinates. [10]
- b) At large distaunnce from its source, electric dipole radiation has fields
- $\mathbf{E} = a_E \sin\theta \frac{e^{i(k.r-i\omega t)}}{r}\hat{\theta}$ and $\mathbf{B} = a_B \sin\theta \frac{e^{i(k.r-i\omega t)}}{r}\hat{\theta}$, Show that the Maxwell's equations
- $\nabla \times \mathbf{E} = -\frac{\partial B}{\partial t}$ and $\nabla \times \mathbf{B} = \frac{\partial E}{\partial t}$ are satisfied if we take $\frac{\partial B}{\partial E} = \frac{\omega}{k} = c$ [10]
- Q.No.2.
- a) Prove Rodrigue's formula for the Legender Polynomials
- i.e., $P_n(x) = \frac{1}{2^n n!}\frac{d^n}{dx^n}(x^2-1)^n$ [10]

  b) For the Legender's Polynomials
- Prove that , $P_l(-\omega) = (-1)^l P_l(\omega)$ [10]
- Q.No.3.
- a) $\int_{-\infty}^{\infty} \frac{x \sin 2x}{(x^2+9)(x^2+1)} dx$ [10]
- ii) $\int_0^{2\pi} \frac{1+2\cos\theta}{5+4\cos\theta} d\theta$ [10]
- Q.No.4.
- a) If $f(z) = u + iv$ analytic with derivative $f'(z)$ which is continuous at all points on a simple closed curve 'C', prove that $\oint_C f(z)dz = 0$. [10]

  b) Prove Cauchy's theorem for multiple connected region. [10]
- Q.No.5.
- a) Define proper and improper orthogonal transformations. [10]
- b) State inner and outer products od a cartesian tensor. Elaborate your answer by giving two examples of each and using the transformation laws of tensor of rank not less than 2. [10]

Section-II

- Q.No.6.
- a) Find the Fourier transformation of the Gaussian probability function $f(x) = Ne^{-\alpha x^2}$ where N and α are constants. [10]
- b) Find the Fourier Cosine transformations of $2e^{-5x} + 5e^{-2x}$. [10]
- Q.No.7.
- a) Find the eigen values and eigen functions using boundary conditions [10]
- $y(1) = o$, and $y'(e^{2x}) = 0$, for
- $x(xy')' + \lambda y = 0$
- b) Find the Green's function for the operator $\alpha = -a^2\frac{d^2}{dx^2} + 1$ in the region $[-\infty, +\infty]$ under the boundary condition $G(-\infty, x') = 0 = G(\infty, x')$. [10]
- Q.No. 8.
- Show that,
- a) $\int_0^{\frac{\pi}{2}} J_0(x\cos\theta)\cos\theta d\theta = \frac{\sin x}{x}$
- b) $\int_0^{\frac{\pi}{2}} J_1(x\cos\theta)\, d\theta = \frac{1-\cos x}{x}$ [10+10]

  Q.No.9.

  a) Prove that [10]

  i) $P_n^0(x) = P_n(x)$,
- ii) $P_n^m(x) = 0$, if $m > n$

  b) If $f(z)$ is analytic in a simply connected region,
- Prove that $\int_a^b f(z)dz$ is independent of the path joining any two points 'a' and 'b' in R. [10]

UNIVERSITY OF THE PUNJAB

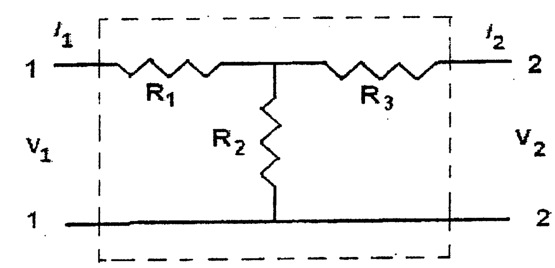
Part-I A/2018
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics
PAPER: V (Electronics)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 100

Instruction: - Attempt any Five questions Selecting at least One from each Section.

Q. No.	Questions	Marks
	Section I	
Q.1	(a) Draw the circuit of full wave (center tapped transformer) rectifier with π filter and find the expression for ripple factor and V_{dc} in it.	10
	(b) Determine the load resistance, ripple factor and V_{rms} for full wave rectifier with π-filter at 50 Hz frequency having $C_1 = C_2 = 50\ \mu F$, $L = 5$ H and $R_C = 200\ \Omega$, with a load taking 200 mA at 125V dc.	8
	(c) Draw the circuits and wave form for double diode clipper.	2
Q.2	(a) Why the h-parameters are called hybrid parameters? How would you convert an active one port network into its equivalent (i) Voltage source and (ii) Current source.	10
	(b) Calculate the h-parameters for the two port circuit given below with $R_1 = 5\ \Omega$, $R_2 = 15\ \Omega$ and $R_3 = 12\ \Omega$. Draw the equivalent circuit. 	8
	(c) What is meant by matching a load?	2
Q.3	(a) Draw the g_m-model equivalent circuit of Common-emitter amplifier and derive the expression for A_{ve}, A_{ie}, R_{ie} and R_{oe}.	10
	(b) In a Common-collector amplifier we use R = 2 KΩ and $h_{fe} = 25$, $h_{ie} = 900\ \Omega$, and $h_{oe} = 16 \times 10^{-6}$ mho. Calculate g_m, A_{ve}, A_{ie}, R_{ie}, R_{oe} and power gain in dB.	10
	Section II	
Q.4	(a) Why the gain of RC coupled amplifier reduces at low and high frequencies.	4
	(b) Discuss the high frequency response of RC coupled amplifier and find the expression for $A_{v(high)}$ and phase angle θ.	10
	(c) A transistor has $C_{be} = 36$ pF, $C_{bc} = 4.0$ pF, $h_{ie} = 950\ \Omega$, $h_{fe} = 190$ and $R_c = 1.2$ KΩ, then find out its Miller input capacitance C_{ie}.	6
Q.5	(a) Explain the construction; draw the symbol and working of n-channel MOSFET in enhancement mode with the help of its characteristics.	10
	(b) Describe four-resistor bias network by using FET.	8
	(c) Why JFET cannot work in enhancement mode.	2
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) Discuss the effect of negative feedback on Bandwidth of an amplifier.	7
	(c) Name four advantages provided by negative feedback.	3
	Section III	
Q.7	(a) Write the tow conditions of sustained oscillation.	5
	(b) Draw the circuit and find expression for frequency in practical Hartley oscillator.	10
	(c) In a Colpitt oscillator $C_1 = C_2 = C$, and L = 150 μH. Find C when f = 1.5 MHz.	5
Q.8	(a) Explain the working of class B push-pull amplifier and find its maximum efficiency.	12
	(b) What is the use of phase inverter? Draw the circuit of double transistor phase inverter and write its operation.	6
	(c) Define second-harmonic distortion.	2
Q.9	Write a note on any **two** of the following.	
	(i) The operational amplifier.	10
	(ii) Darlington compound transistor.	+
	(iii) Monostable multivibrator.	10