UNIVERSITY OF THE PUNJAB

Part-I **A/2017**
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 1

Q. No. 1 Discuss spherical polar coordinates and derive expression for the scale factors of this system. (20)

Q. No.2. (a) Derive the expression for the Legender's Polynomials $P_0(x)$, $P_1(x)$, $P_2(x)$, $P_3(x)$ and $P_4(x)$ using recurreuce relation for the coefficients given by $C_{m+2} = \frac{m(m+1)-n(n+1)}{(m+1)(m+2)}C_m$ and the Legender's Polynomials of degree n given by $P_n(x) = \frac{(2n-1)(2n-3)(2n-5)...5.3.1}{n!}[x^n - \frac{n(n-1)}{2(2n-1)}x^{n-2} + \frac{1}{8}\frac{n(n-1)(n-2)(n-3)}{(2n-1)(2n-3)}x^{n-4} + ...]$.

(b) Sketch the graphs of $P_0(x)$, $P_1(x)$, $P_2(x)$, $P_3(x)$ and $P_4(x)$. (10+10=20)

Q No.3. Evaluate

(i) $\int_0^{2\pi} \frac{cos3\theta}{5-4cos\theta}d\theta$ (10)

(ii) $\int_0^{2\pi} \frac{d\theta}{a+bcos\theta}d\theta$, where $a > b > 0$ (10)

Q. No. 4. (a) Show that Cauchy-Remann equations are satisfied for $w(z) = e^{-\frac{1}{z^4}}$. (10).

(b) Evaluate the integral $\int_0^{1+i}(x^2-iy)dz$ (i) along the straight line $y = x$ (ii) along the curve $y = x^2$. (5+5)

Q. 5. (a) Define a tensorial quantity. Give two examples of it.
(b). Prove that

$$A_{pq} = \begin{pmatrix} x_2^2 & -x_1x_2 \\ -x_1x_2 & x_1^2 \end{pmatrix}$$ (20)

are the components of a second rank tensor in 2-D.

Section-II

the

Q.6. (a) Prove that eigen values of Strum Liouville's problems are real

b) Find the Green's function for the operator $\alpha = -\frac{d^2}{dx^2} - 4$ in the region $[0,1]$ under the boundary conditions $G(0) = 0, G'(1) = 0$ (20)

P.T.O.

Q. 7. (a) Find the Fourier series of $f(x)$ given by if

$$f(x) = \begin{cases} -\pi, & -\pi < x < 0 \\ x, & 0 < x < \pi \end{cases}$$

(10+10=20)

(b) Find the Fourier transformation of Slit function defined as :

$$f(t) = \begin{cases} 1, & -a \le t \le a \\ 0, & \text{otherwise} \end{cases}$$

Q. No. 8. (a) Sketch the followings

(2+2+2+2+2=10)

(i) $|z - a| = \rho$

(ii) $|z - a| < 3$

(iii) $|z + 2 + 3i| \le 2$

(iv) $|z| > 3$

(v) $2 < |z| < 4$

(b) If there is some common region in which $w_1 = u + v$ and $w_1 = u - iv$ are both analytic, prove that u and v are constants. (10)

Q9(a): For Bessel functions, prove that,

(10+10=20)

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

b) Show that

$$J_{n-1}(x) + J_{n+1}(x) = \frac{2n}{x} J_n(x)$$

UNIVERSITY OF THE PUNJAB

Part-I A/2017
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics
PAPER: II (Classical Mechanics)

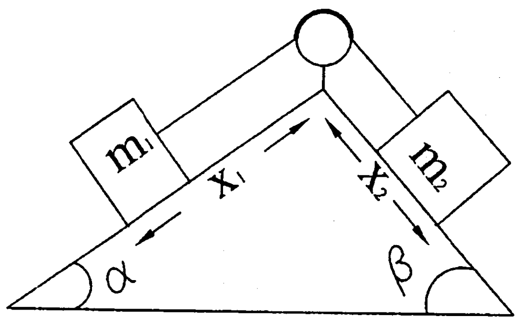
TIME ALLOWED: 3 hrs.
MAX. MARKS: 50

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

SECTION I

1(a) If L is a Lagrangian for a system of n degrees of freedom satisfying Lagrange equation of motion, show by direct substitution that $L' = L + \frac{d}{dt}F(q_1, q_2, ..., q_n; t)$, also satisfies the Lagrange's equation of motion, where F is an arbitrary differentiable function of its arguments.

(b) Consider two masses tied together on a frictionless inclined plane as shown in the figure. Find the equations of motion.



(c) A buzzing fly moves in a helical path given by $x(t) = (b\sin\omega t, b\cos\omega t, ct^2)$. Show that the magnitude of the acceleration of the fly is constant provided b, ω and c are constants. [4,4,4.5]

2(a) State the D'Alembert's principle and use it to derive the Lagrange's equation of motion $\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_i}\right) - \frac{\partial L}{\partial q_i} = 0$, where $L = L\left(q_i, \dot{q}_i, t\right)$ is the Lagrangian of the dynamical system.

(b) Obtain the Lagrange equation of the second kind $\frac{dL}{dt} - \frac{d}{dt}\left(L - \dot{q}_i \frac{\partial L}{\partial \dot{q}_i}\right) = 0$.

(c) A bead slides along a smooth wire bent in the shape of a parabola $z = cr^2$. The bead rotates in a circle of radius R when the wire is rotating about its vertical axis with angular velocity ω. Find the value of c. [4,4,4.5]

3(a) Consider the motion of particle in a central force field V (r) = $-\frac{k}{r}$. Write down the Lagrangian in polar coordinates and integrate the equation of motion to derive

$$\theta(r) = \int \frac{l\,dr}{r^2\sqrt{2\mu\left(E + \frac{k}{r} - \frac{l^2}{2\mu r^2}\right)}} + \text{constant},$$

where E is the total energy and l is the angular momentum. Now, change variables as $u = \frac{1}{r}$ to derive the equation of a conic section $\frac{\alpha}{r} = 1 + \varepsilon\cos\theta$.

(b) Use the above expressions to derive Kepler's third law of planetry motion. [7.5,5]

4(a) Two point like masses M_1 and M_2 are connected by massless thread which rests on a wheel (Atwood's Machine). The motion is assumed to be frictionless. Obtain the Lagrange equation of motion.

(b) A particle of mass m moves without friction under the action of gravitation on the inner surface of a paraboloid, given by $x^2 + y^2 = az$. Use the method of Lagrange multipliers to determine the Lagrangian and the equations of motion. Show that the particle moves on a horizontal circle in the plane z = h, provided that it gets an initial angular velocity. Find this angular velocity.

(c) Show that the geodesic on the surface of a sphere is a segment of great circle. [4,4,4.5]

P.T.O.

SECTION II

5(a) A particle of mass m moves in a central force field with potential $-\frac{k}{r}$. The Lagrangian is $L=\frac{1}{2}m\left(\dot{r}^2+r^2\dot{\theta}^2+r^2\sin^2\theta\dot{\phi}^2\right)+\frac{k}{r}$. (i) Find the momenta (p_r, p_θ, p_ϕ). (ii) Find the Hamiltonian $H = H(r,\theta,\phi,p_r,p_\theta,p_\phi)$. (iii) Write down Hamilton's Equations.

(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) Show that the Hamiltonain for a simple harmonic oscillator $H=\frac{p^2}{2m}+\frac{1}{2}m\omega^2x^2$ can be written in the form $H = \omega a^* a$, where $a=\sqrt{\frac{m\omega}{2}}\left(x+\frac{ip}{m\omega}\right)$, $a^*=\sqrt{\frac{m\omega}{2}}\left(x-\frac{ip}{m\omega}\right)$.

Show that $\{a,a^*\}=-i$, $\{a,H\}=-i\omega a$, $\{a^*,H\}=i\omega a^*$.

(c) Show that the path followed by a particle in sliding from one point to another in the absence of friction in the shortest 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 $Q = q\tan p$, $P = \log(\sin p)$, is canonical transformation.

(c) Show that the Poisson bracket obeys the Jacobi identity $\{A,\{B,C\}\}+\{B,\{C,A\}\}+\{C,\{A,B\}\} = 0$, where A, B and C are arbitrary dynamical variables. [4, 4, 4.5]

UNIVERSITY OF THE PUNJAB

Part-I A/2017
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) State any three postulates of Quantum Mechanics.

(b). Prove that eigenfunctions of same Hermitian operator belonging to distinct eigenvalues are always orthogonal.

(9+11)

Q2. a) If Ψ is an eigenfunction of Hamiltonian $\hat{H}$, with eigenvalue E. What is the expectation value of $\hat{H}$ in the state Ψ such that Ψ is normalized to unity.

1. (b) If Ψ_1, Ψ_2, Ψ_3 are normalized eigenfunctions of a Hermitian operator belonging to distinct eigenvalues, derive the condition to be satisfied by the coefficients $c_1, c_2, \cdots, c_n$ if Ψ is a wavefunction normalized to unity

$$\Psi = c_1\Psi_1 + c_2\Psi_2 + \cdots c_n\Psi_n.$$

Which of the following wavefunctions are acceptable if every wavefunction is normalized to unity and why?

i $\Psi = \frac{-1}{\sqrt{2}}\Psi_1 + \frac{1}{2}\Psi_2 + \frac{1}{2}\Psi_3,$

ii $\Psi = \sqrt{\frac{1}{2}}\Psi_1 + \frac{1}{2}\Psi_2 + \frac{1}{3}\Psi_3,$

iii $\Psi = \sqrt{\frac{1}{3}}\Psi_1 + \sqrt{\frac{1}{3}}\Psi_2 + \sqrt{\frac{1}{3}}\Psi_3.$

(6+8+6)

Q3. (a) Show that the time rate of change of expectation value of an operator $\hat{A}$ is given as

$$\frac{d}{dt}\left\langle \hat{A}\right\rangle = \frac{1}{i\hbar}\left\langle\left[\hat{A},\hat{H}\right]\right\rangle + \left\langle\frac{\partial\hat{A}}{\partial t}\right\rangle.$$

State the conditions when operator $\hat{A}$ is a constant of motion.

1. (b) If

$$\hat{H} = \frac{-\hbar^2}{2m}\nabla^2 + V(x,y,z)$$

show that

$$\left[\hat{H},\hat{p}_x\right] = i\hbar\frac{\partial V}{\partial x}.$$

Using the equation for the time rate of change of expectation values show that

$$\frac{d}{dt}\langle\vec{p}\rangle = -\left\langle\vec{\nabla}V\right\rangle,$$

where $\vec{p} = p_x\hat{\imath} + p_y\hat{\jmath} + p_z\hat{k}$.

(10+10)

PTO

Section II

Q4. Solve the Schrödinger wave equation for a finite square well potential for the case when $0 < E < V_0$, where

$$V(x) = \begin{cases} V_0, & x < -\frac{a}{2} \\ 0, & -\frac{a}{2} < x < \frac{a}{2} \\ V_0, & x > \frac{a}{2} \end{cases}$$

(20)

Q5. (a) Show that in spherical polar coordinates

$$\hat{L}_z = -i\hbar\frac{\partial}{\partial\phi}.$$

1. (b) Show that the eigenvalue spectrum of $\hat{L}_z$ is given by $m\hbar$ where $m = \cdots -1, 0, 1, \cdots$.

   (c) Complete the following equations

$$\hat{L}^2 Y_{lm} = ?,$$
$$\hat{L}_z Y_{lm} = ?.$$

(8+8+4)

Q6. (a). Define fermions and bosons. Write down the expressions for the wave functions for

(i). three identical bosons

(ii). three identical fermions

(b). What is exchange degeneracy? Also define Exchange operator. Show that exchange operator commutes with Hamiltonian.

(9+11)

Section III

Q7.Obtain the expression for the first order correction in energy and wave-function by using time independent perturbation theory.

(20)

Q8. Write down the general method of determining ground state energy and wave function by variational technique.

(20)

Q9. a) Write down (do not derive) the equation of generalized uncertainty principle.

1. (b) Which of the following pairs of observables can or cannot be determined simultaneously with zero uncertainties and why?

   i x and p_x,

   ii p_z and L_Z,

where x, p and L represent the position, linear momentum and orbital angular momentum variables respectively.

1. (c) Use generalized uncertainty relation to show that

$$(\Delta x)(\Delta p_x) \geq \frac{\hbar}{2}$$

(4+8+8)

UNIVERSITY OF THE PUNJAB

Part-I A/2017
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics **TIME ALLOWED: 3 hrs.**
PAPER: IV (Solid State Physics-1) **MAX. MARKS: 50**

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

Section- 1

Q.1(a) Define the following giving one example in each case:

(i) Primitive cell (ii) Coordination number (iii) Bravias Lattice (iv) Lattice symmetry operations (2+2+2+2)

(b) Draw a $(11\bar{1})$ plane in the unit cell of cubic crystal. Find the <110> direction that lie on this plane. (4.5)

Q.2 (a) Explain the crystal structure of Sodium Chloride in detail. (5)

(b) Consider (hkl) plane in a crystal system, prove that the reciprocal lattice vector $G = hb_1 + kb_2 + lb_3$ is perpendicular to this plane and the distance between two adjacent parallel planes of lattice is $d_{hkl} = 2\pi/|G|$ (7.5)

Q.3 (a) What do you mean by the Brillouin zone, how it is related to the diffraction conditions in the reciprocal lattice. Prove that the reciprocal lattice of a simple cubic lattice is also simple cubic, also describe its first Brillouin zone. (8)

(b) Given that the primitive translation vectors are

$$a_1 = 3^{1/2}\frac{a}{2}\hat{x}, \qquad a_2 = -3^{1/2}\frac{a}{2}x + \frac{a}{2}\hat{y}, \qquad a_3 = c\hat{z}$$

Find the primitive translation vectors of the reciprocal lattice. (4.5)

Q.4. (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. (8.5)

(b) Define the elastic compliance and elastic stiffness constants with their respective units. (4)

Section- 11

Q.5 Derive the dispersion relation of phonons in a diatomic crystal, sketch it in the first Brillion zone and explain the significance of the optical and acoustic branch. (12.5)

Q.6 Differentiate between following (12.5)

i) Schottky and Frenkel defects

ii) Edge and Screw dislocations

iii) F- centres and V- centres

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

i) The Diamond structure

ii) Ficks law of diffusion in solids

UNIVERSITY OF THE PUNJAB

Part-I A/2017
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics
PAPER: V (Electronics)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 100

NOTE: Attempt any FIVE questions selecting at least ONE from each Section.

Section I

Q.1 **(a)** Draw the circuits and explain the circuit operation with the help of wave form for; **(i)** diode clamper. **(ii)** double diode clipper — 10

(b) Sketch the circuit of full wave (center tapped transformer) rectifier circuit with Pi (π) filter, discuss its operation and derive the expression for its ripple factor. — 8

(c) Why diodes carry short current pulses when a capacitor filter is used. — 2

Q.2 **(a)** Draw the h-parameter equivalent circuit of Common Emitter transistor amplifier and find the expression for voltage gain, current gain, input and output resistances. — 10

(b) A transistor with the following parameters is employed in a Common Emitter amplifier; R = 1000 Ω, h_{ie} = 1.5 KΩ, h_{fe} = 40, and $h_{oe} = 16 \times 10^{-6}$ mho. Calculate g_m, A_{ve}, A_{ie}, R_{ie}, R_{oe} and power gain in dB. — 8

(c) If α (alpha) is given, how do you determine β (beta). — 2

Q.3 **(a)** Draw the circuit of four resistors bias network and find the relation for Its collector current and stabilizing ratio. — 10

(c) Determine the design values for four resistors bias circuit with V_{CC} = 20V, I_C = 6 mA, h_{fe} = 60, V_{BE} = 0.6V, $V_{CE} = 0.5 \times V_{CC}$, $V_E = 0.1 \times V_{CC}$, $I_1 = I_2 = 10 \times I_B$. — 10

Section II

Q.4 **(a)** Discuss the low frequency response of RC coupled amplifier and find the expression for $A_{v(low)}$ and phase angle θ. — 10

(b) Find the expression which show the reduction in gain in the presence of unbypassed emitter resistor R_E — 6

(c) Why f_1 and f_2 are called half power frequencies? — 4

Q.5 **(a)** Describe the construction, draw the symbol and explain the action of n-channel MOSFET in depletion mode. — 10

(b) Describe how pinch-off is obtained in an n-channel JFET. — 7

(c) Trace the internal FET circuit arranged as two port network. — 3

Q.6 **(a)** Draw the equivalent circuit of a current-series feedback circuit and determine its voltage gain and β with feedback, and input and output resistances. — 12

(b) For a current-series feedback circuit, there used R_E = 1500 Ω, R = 10 KΩ, h_{fe} = 50 and $h_{oe} = 10^{-4}$ moh. Find the gain, input and output resistances with and without feedback. — 6

(c) What is the effect of negative feedback on Bandwidth. — 2

Section III

Q.7 **(a)** What is an oscillator? Discuss the practical Colpitts oscillator and determine the relation for its frequency. — 10

(b) Discuss briefly the crystal control of frequency. Draw the crystal's equivalent circuit and find resonance frequency for its series and parallel models. — 10

Q.8 **(a)** Describe class B push-pull power amplifier in detail and find out expression for its power efficiency. — 12

(b) What is an ideal transformer? Show that a load in the secondary appears in the primary as a resistance, with ac voltage applied. — 6

(c) What is the purpose of phase inverter? — 2

Q.9 Write a note on any **two** of the following. — 10 + 10

(i) Monostable multivibrator

(ii) Logic Gates

(iii) The two port network