UNIVERSITY OF THE PUNJAB

Roll No. ....

M.A./M.Sc. Part – I Annual Examination – 2020

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

Q. No.1.

a) Discuss cylinderical polar coordinates and derive expression for the scale factors of this system. [20]

Q.No.2.

Derive the expression for sherical harmonics $Y_0^0(\theta,\varphi)$, $Y_1^0(\theta,\varphi)$, $Y_{+1}^{-1}(\theta,\varphi)$, $Y_2^2(\theta,\varphi)$ and $Y_2^1(\theta$

$Y_n^m(\theta,\varphi) = \left(\frac{(2n+1)(n-m)!}{4\pi(m+n)!}\right)^{\frac{1}{2}} P_n^m(\cos\theta)\, e^{im\varphi}$ and $P_n^m(x)\frac{(1-x^2)^{\frac{m}{2}}}{2^n n!}\frac{d^{n+m}}{dx^{n+m}}(x^2-1)^n$

Q.No.3.

Evaluate i) $\int_0^\infty \frac{\sin x}{x(x^2+1)}dx$ ii) $\int_0^{2\pi} \frac{(x^2+4)\sin mx}{x(x^2+16)}dx$ [10 + 10]

Q.No.4.

a) Prove the following Cauchy's integral formula for the derivative:

$f^n(x) = \frac{n!}{2\pi i}\oint_C \frac{f(z)}{(z-a)^{n+1}}dz$; n=1,2,3,4,............. [10]

b) Evaluate the integral $\oint_C \frac{e^{2z}}{z^4}dz$,where c; $|z|=1$ [10]

Q.No.5.

The position vector $\bar{r}$ of a point P has coordinates (x_1, x_2, x_3) in an un-primed frame of reference . If the frame of reference is rotated through an angle θ about the origin in the anticlockwise direction , the new coordinates of P are $\left(x_1', x_2', x_3'\right)$ in the primed frame of reference , Derive the transformation law $x_i' = a_{ip}x_p$ for the vector $\bar{r}$. [20]

SECTION – I

Q.No.6.

$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty}\left\{a_n\cos\frac{n\pi x}{L} + b_n\sin\frac{n\pi x}{L}\right\}$

Then find the complex sereis of $f(x)$ given by

$f(x) = \sum_{n=-\infty}^{\infty} C_n e^{i\frac{n\pi x}{L}}$, where $n = 0, \pm1, \pm2, \pm3, \ldots$, [20]

Q.No.7. (10+ 10)

a) Show that $xJ_n'(x) = xJ_{n-1}(x) - nJ_n(x)$

b) Prove that i) $\cos(x\sin\theta) = J_0(x) + 2\sum_{n=1}^{\infty} J_{2r}(x)\cos(2r\theta)$

ii) $\sin(x\sin\theta) = 2\sum_{r=1}^{\infty} J_{2r-1}(x)\sin(2r-1)\theta$

Q.No.8. (10+10)

a) Express $\frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z}$ in cylinderical coordinates.

b) Show that

$$A = \begin{bmatrix} \frac{1}{2} & \frac{\sqrt{3}}{2} & 0 \\ 0 & 0 & 1 \\ -\frac{\sqrt{3}}{2} & \frac{1}{2} & 0 \end{bmatrix}$$

carries an improper orthogonal Transformation. (10+10)

Q.No.9.

a) Find the Green's Function solution , wityh boundary conditions

$G\left(0,x'\right) = 0 = G\left(1,x'\right)$ for

$\frac{d^2G}{dx^2} + K^2G = -\delta(x-x')$

b) For the eigen value problem $y'' + \lambda y = 0, where\ \ y(0) = 0,\ \&\ y(\pi) = 0$ obtained the set of eigen functions and values.

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M.A./M.Sc. Part – I Annual Examination – 2020

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 without friction under the action of gravitation on the inner surface of paraboloid, which is given by

$$x^2 + y^2 = ax$$

and having kinetic energy

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

a) Construct the Lagrangian and derive the equation of motion for r by using Euler Lagrange equation. (04)

b) 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. (04)

c) Show that the particle oscillates about the circular orbit if it is displaced only weakly. Determine the oscillation frequency. (4½)

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. (04)

b) Use the effective potential to discuss the qualitative nature of the orbits for different values of the energy and the angular momentum. (04)

c) Show that if the orbit is nearly circular, the apsides will advance approximately by $\frac{\pi\rho}{a}$ per revolution, where p is the radius of the circular orbit. (4½)

Q.3. a) Discuss the motion of a body of mass μ in a central force field with the Lagrangian (06)

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

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 (6½)

$$r = kexp(\alpha\theta)$$

where k and α are constants. Also calculate the total energy of the orbit.

SECTION – II

Q.4. a) Using the fundamental Poisson brackets find the values of α and β for which the equations (04)

$$Q = q^\alpha cos\beta p, \qquad P = q^\alpha sin\beta p$$

represent a canonical transformation.

b) For what values of α and β, do these equations represent an extended canonical transformation? Find a generating function of the F_3 form for the transformation. (06)

c) On the basis of part (b), can the transformation equations be modified so that they describe a canonical transformation for all values of β?. (2½)

Q.5. a) Prove that the Poisson bracket of two constants of the motion is itself a constant of the motion even when the constants depend upon time explicitly. (04)

b) Show that if the Hamiltonian H and a quantity F are constants of the motion, then the nth partial derivative of F with respect to t must also be a constant of the motion and further show that if A and B are any two integrals of motion of a dynamical system, their Poisson bracket is also an integral of motion. (04)

c) As an illustration of this result, consider the uniform motion of a free particle of mass m. The Hamiltonian is certainly conserved, and there exists a constant of the motion (4½)

$$F = x - \frac{pt}{m}$$

Show by direct computation that the partial derivative of F with t, which is a constant of the motion, agrees with [H, F].

Q.6. a) Define the phase space, phase volume and Liouville's theorem also show that the phase space volume of a canonical system is invariant under canonical transformations. (08)

b) The system consists of particles of mass m in a constant gravitational field, for the energy we have (4½)

$$E = \frac{p^2}{2m} - mgy$$

then apply the Liouville's theorem to show that the density of the system of points in phase space remains constant.

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 (04)

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

then find Hamilton's equations of motion.

b) Construct the equation of motion for the system by using Hamilton's equation with Lagrangian is (4½)

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

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. (04)

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M.A./M.Sc. Part – I Annual Examination – 2020

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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

Q1. (a) Define state vector. Also give its physical significance.

(b) State correspondence principal.

(c) Define the following operators

(i) Parity operator

(ii) Hamiltonian operator

(iii) Skew Hermitian operator

(iv) Projection operator

(v) Ladder operator (5+5+10)

Q2. (a) Derive the expression for time rate of change of expectation value of an operator $\hat{A}$.

(b) Consider two states

$$|\Psi 1> = 2i|\Phi_1> + |\Phi_2> - a|\Phi_3> + 4|\Phi_4>$$

$$|\Psi 2> = 3|\Phi_1> - i\,|\Phi_2> + 5\,|\Phi_3> - |\Phi_4>$$

Where $|\Phi_1>, |\Phi_2>, |\Phi_3>$ *and* $|\Phi_4>$ are orthonormal kets and 'a' is constant. Find the value of 'a' if $|\psi 1>$ and $|\psi 2>$ are orthogonal. (12+8)

Q3. A free particle is moving in one dimension stationary state whose wave function is

$$\Psi = 0 \text{ for } x < -a$$

$$\Psi = A\left(1 + \cos\frac{\pi x}{a}\right) for -a < x \leq a$$

$$\psi = 0\ for\ x > a$$

where a, A are constants

(i) Is this physically acceptable wave function.
(ii) Find A so that ψ is normalized to unity.
(iii) Find classically allowed region. (20)

Section II

Q4. Consider a beam of particles of mass m that are sent from left to potential barrier

$$V(x) = \begin{Bmatrix} 0 & for\, x < 0 \\ V_0 & for\, 0 \leq x \leq a \\ 0 & for\, x > a \end{Bmatrix}$$

For the case $E>V_0$ calculate Reflectance and Transmittance coefficients. (20)

Q5. (a) Define angular momentum in quantum mechanics obtain the eigen value for L_Z.

(b) Given that in spherical polar coordinates $L_z = -i\hbar\frac{\partial}{\partial\phi}$, show that

$[L_z, \cos\Phi] = i\hbar \sin\Phi$; $[L_z, \sin\Phi] = -i\hbar\cos\Phi$

(c) Z component of angular momentum and azimuthal angle Φ can be be measured with precisionat same time or not? (8+8+4)

Q6. (a) State and explain generalized pauli's principle.

(b) Construct symmetric and antisymmetric wave function for the system of three noninteracting particles.

(c) What are fermions and bosons? Which kind of statistics do they obey? Give example of each. (6+8+6)

Section III

Q7. What is perturbation theory? Write detail description of time independent perturbation theory upto first order correction of energy and wave function? (20)

Q8. (a) Why schordinger wave equation is not suitable for each system. What are approximation methods?

(b) Determine ground state energy of a particle in a box having width 'a' using variational method. (6+14)

Q9. (a)What are pictures of quantum mechanics? Describe them briefly.

(b) Use generalized uncertainty relation to obtain the uncertainty between $L^2$and L_z

(10+10)

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M.A./M.Sc. Part – I Annual Examination – 2020

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: (a)-Explain crystal structure of sodium chloride. Draw a sketch of sodium chloride lattice and write down the coordinates of atoms in the cell. What is number of sodium ions in a unit cell of NaCl? 5.5

(b)-What do you mean by direction indices? How they can be found? Indicate following direction $[1\bar{1}1]$, $[\bar{1}10]$, $[121]$ in cubic unit cells. 02 + 02 + 03

Q.2: (a)-Explain Bragg law for X-ray diffraction in crystal. 05 + 7.5

(b)-The primitive translation vectors of hexagonal space lattice may be taken as,

$$\vec{a} = \frac{\sqrt{3}a}{2}\hat{i} + \frac{a}{2}\hat{j}, \quad \vec{b} = -\frac{\sqrt{3}a}{2}\hat{i} + \frac{a}{2}\hat{j}, \quad \vec{c} = c\hat{k}$$

Find volume, basis vectors of reciprocal lattice and form first Brillouin zone.

Q.3: What are ionic crystals and ionic bonding? State properties of ionic crystals. What are different contributions to potential of an ionic crystal? Obtain an expression for cohesive energy of ionic crystals. 12.5

Q.4: (a)-Show that dispersion relation for lattice waves in a mono-atomic linear lattice of mass m, spacing a and nearest neighbor interaction constant C is,

$$\omega = 2\sqrt{\frac{C}{M}}\sin\frac{ka}{2}$$

where ω is angular frequency and $\vec{k}$ is wave vector. What are allowed values of phonon wave vector? 10

(b)-Show that for mono-atomic lattice, phase velocity and group velocity is same for long wavelength. 2.5

Section – II

Q.5: (a)-What are basic assumptions in classical model, Einstein model and Debye model of phonon heat capacity? 06 + 3.5+ 03

(b): Explain anharmonic crystal imteractions.

(c): What is thermal conductivity? How do you define thermal conductivity coefficient 'K'?

Q.6: (a)-What is meant by crystal imperfections? Give their different types that are found in solid materials. 03 + 07 + 2.5

(b): What is a color center? Describe F-center in alkali halides.

(c)-Explain difference between edge and screw dislocations.

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

(a)-Low energy excitations in amorphous solids

(b)-Shear strength of single crystals

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M.A./M.Sc. Part – I Annual Examination – 2020

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) Define barrier potential. Sketch and explain energy diagrams illustrating the formation of the pn junction and depletion region.	10
	(b) What are the LED and Zener diode? Draw their symbols, explain their performances and uses.	8
	(c) Define the reverse saturation current and write the cause of it.	2
Q.2	(a) Explain the input and output characteristics of npn transistor in common emitter configuration.	10
	(b) Using pnp transistor draw the circuits for three types of amplifiers.	6
	(c) Express the power gain, voltage gain and current gain in decibel.	4
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 stabilizing ratio when $I_C = 3$ mA, $V_{BE} = 0.5V$, $h_{fe} = 75$, $V_{CC} = 15V$, $V_{CE} = 0.5V_{CC}$	10
	Section II	
Q.4	(a). What is construction difference in depletion mode and enhancement mode MOSFET?	4
	(b) Explain the construction and working of n-channel MOSFET in depletion mode.	10
	(c) Define three parameters of JFET and derive the relation between them	6
Q.5	(a) What is miller effect? Sketch the high frequency equivalent circuit for the C-E amplifier and find the relation for Miller input capacitance C_{ie}.	10
	(b) Draw the equivalent circuit of C-E amplifier with unbypassed emitter resistor R_E and prove that gain is reduced due to not using C_E.	10
Q.6	(a)Derive the relation between gain with feedback and gain without feedback.	5
	(b) Write the advantages of negative feedback and discuss how negative feedback (i) stabilize the gain, (ii) improve the bandwidth.	8
	(c) Discuss voltage feedback with FET.	7
	Section III	
Q.7	(a) Draw the circuit and explain the operation of Monostable multivibrator. Find the relation for pulse width in it.	10
	(b) Write the Boolean equation, symbol, truth table and DTL circuit of OR and NAND gate.	5
	(c) In an Astable multivibrator $R_1 = 2.7$ KΩ, $C_1 = 1000$ pF, $R_2 = 5.2$ KΩ and $C_2 = 1500$ pF. Find the frequency.	5
Q.8	(a) Discuss oscillator feedback principle.	5
	(b) Explain the working of practical Hartley oscillator and find the relation for its frequency.	10
	(c) In Hartley oscillator $L_1 = 250$ μH, $L_2 = 50$ μH and $C = 300$ pF. Then find out frequency.	5
Q.9	Write a note on any **two** of the following. (i) Full wave (center tapped transformer) rectifier. (ii) Construction and working of npn transistor. (iii) Class B push-pull amplifier	10 + 10