UNIVERSITY OF THE PUNJAB

M.A./M.Sc. Part – I Supply – 2020 & Annual – 2021

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

Q 1(a): State and prove Gauss' divergence theorem.

Q 1(b): Show that in spherical polar coordinate system
$\vec{\nabla} \times \left(\cos\theta\ \vec{\nabla}\phi\right) = \vec{\nabla}.\left(\frac{1}{r}\right)$ where, r, θ and ϕ are spherical polar coordinates.

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

Q 2(b): Define a tensor. Discuss outer and inner products of a cartesian tensor. Explain each with an examlple.

Q 3(a): Using Laplace Transformation, solve $x'' + n^2 x = a\sin(pt)$; $x(0) = 1, x'(0) = 3$, where "n","p" and "a" are real constants.

Q 3(b):Find the Fourier Cosine and Sine transformation of $e^{-\beta x}$.

Q 4(a): Derive the Rodrigue's formula for the Legender polinomials
$p_n(x) = \frac{1}{2^n n!}\frac{d^n}{dx^n}(x^2-1)^n$

Q 4(b): Evalute $P_3^3(x), P_4^4(x)$ at $x = \cos\theta$, $x = \sin\theta$

Q 5(a): For the Bessel's function, show that
$\frac{d}{dx}\left[x^{-n} J_n(x)\right] = -x^{-n} J_{n+1}(x)$

Q 5(b): Prove that $e^{-\frac{x}{2}\left(t-\frac{1}{t}\right)} = \sum_{n=-\infty}^{+\infty} J_n(x)\, t^n$

P.T.O.

SECTION – II

Q 6(a): For the eigen value problem
$y'' + \lambda y = 0$,where $y(0) = 0, y(\pi) = 0$,
obtain the set of eigen functions and values. [10]

Q 6(b):Find the Green's function for the operator
$\alpha = -\frac{d^2}{dx^2} - 4$,in th region $[0, 1]$ under the boundary conditions
$G(0) = 0$ and $G'(1) = 0$. [10]

Q 7(a): Prove that $u(x, y) = e^x Cosy$ is harmonic.
Find its corresponding harmonic conjugate as well. [10]

Q 7(b): In the quantum theory of photoionization, we encounter the identity $\left(\frac{ia-1}{ia+1}\right)^{ib} = e^{-2b\, Cot^{-1} a}$ in which "a" and "b" are real.
Verify this identity. [10]

Q 8: Evaluate the following integrals

i) $\int_0^{2\pi} \frac{Cos^2 3\theta}{5-4Cos2\theta} d\theta$ ii) $\int_{-\infty}^{+\infty} \frac{Cos\ mx}{x^2-a^2} dx, x > 0, a > 0.$ [20]

Q 9(a): Using tensorial notations, prove that
$\text{curl}(\vec{A} \times \vec{B}) = (div\vec{B})\vec{A} - (div\vec{A})\vec{B} + (\vec{B}.\vec{\nabla})\vec{A} - (\vec{A}.\vec{\nabla})\vec{B}$ [10]

Q 9(b): Find the inverse Laplace transform of $\frac{s}{s^4 + s^2 + 1}$ [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) Explain the Holonomic, Non-holonomic and Scleronomic constraints with examples, at least one for each.

b) Define the virtual displacement and generalized coordinates, also explain with examples.

c) Derive the expression for D'Almbert Principle by applying the principle of virtual work

Q.2.

a) Find the force law for the object of unit mass moving in a logarithmic spiral orbit under the central force field given by

$$r = k\, exp(\beta\, \theta)$$

where k and β are constants.

b) Also find the total energy of the orbit.

c) Calculate the angular moment and torque of system. 4.5+4+4= 12.5

Q.3

a) The Lagrangian of a system consisting on a mass m is suspended by a spring with spring constant k in the gravitational field is given by

$$L = \frac{1}{2}m\left(\dot{r}^2 + r^2\dot{\theta}^2\right) + mgr\cos\theta - \frac{k}{2}(r - r_0)^2$$

where in Lagrangian r_0 is constant and $r = r(t)$, then define the number of degree of freedom for that system and also calculate the all possible generalized momenta.

b) Construct the equations of motions for that systems by using Euler-Lagrange equation

c) Solve the equation of motion for $\theta(t)$ with approximation of small angular displacement. 2+6+4.5= 12.5

<u>**SECTION – II**</u>

Q.4

a) The transformation equations between two sets of the coordinates are

$$Q = \frac{q^2 - p^2}{2}, \qquad P = -\tan^{-1}\frac{q}{p}$$

Show that Q and P are the canonical variables if p and q are

b) Obtain the generating function F that generates this transformation.

6+6.5= 12.5

Q.5

a) Construct the equations of motion for a system with Hamiltonian $H(q_i, p_i, t)$ in Poisson bracket form

b) A particle of mass m moving in a central potential V(r) does not depend on velocity. Find the integral of motion.

c) By using the Poisson bracket show that the following transformation

$$Q = \sqrt{e^{-2q} - p^2}\ , \ P = \cos^{-1}(pe^q),$$

is canonical.

4+4+4.5 =12.5

Q.6

a) Define the followings
   (i) Poisson Bracket for two arbitrary function in phase space
   (ii) Phase volume
   (iii) Liouville theorem.

b) 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.

c) Show that the Poisson brackets are invariant under the canonical transformations.

4.5+4+4= 12.5

Q.7

a) Construct the Hamilton-Jacobi differential equation for 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), $\theta(t)$).

b) Solve the Hamilton-Jacobi differential equation for r(t) and $\theta(t)$.

6+6.5= 12.5

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Roll No. ....

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) Write down following quantities in operator form?

(b) Define the following terms.

(i) Linear momentum.

(ii) Angular momentum.

(iii) Kinetic energy.

(iv) Total energy.

(v) Position.

(c) What is the time evolution in quantum mechanics? Define stationary states and time evolution operator. (10+10)

Q2. (a) Derive equation of continuity. How it explains conservation of particle flow.

(b) Consider a particle moving in one dimensional box of length 'a'. Calculate the probability of finding the particle in region $0<x \leq \frac{a}{4}$ for the states n=1 and n=3. (10+10)

Q3. Consider a system whose wave function is given by

$$\psi = \frac{\sqrt{3}}{3}\psi 1 + \frac{2}{3}\psi 2 + \frac{\sqrt{2}}{3}\psi 3$$

where ψ1, ψ2, and ψ3 are all orthonormal functions.

(*i*) Show that wave function ψ is normalized.

(*ii*) Calculate the probability of finding the system in each state of ψ1, ψ2, and ψ3.

(*iii*) What about total probability?

(b) Define superposition principle. What is it's physical significance? Explain with help of examples. (14+6)

Section II

Q4. Solve the time independent schrodinger wave equation for a potential well for the case $E>V_0$ where

$$V(x) = \begin{Bmatrix} for -\infty < x < 0 \\ Vo \;\; for\; 0 < x < \infty \end{Bmatrix}$$

Calculate Reflectance and Transmittance coefficients. Also show that sum of reflection and transmission coefficients is equal to one. (20)

Q5. (a) Obtain eigen values of L^2 and L_z.

(b) Verify the following commutation relations of pauli spin matrices.

(i).$[\sigma_x, \sigma_y] = 2i\sigma_z$ (ii). $[\sigma_y, \sigma_z] = 2i\,\sigma_x$ (iii).$[\sigma_z, \sigma_x] = 2i\sigma_y$ (10+10)

Q6. (a) Consider a ket $|\psi>$ and bra $<\Phi|$ where

$$|\psi> = \begin{pmatrix} -1+3i \\ 3 \\ 2+3i \end{pmatrix}, <\Phi| = (6 \;\; -i \;\; 5)$$

(i) Find complex conjugate and transpose of $|\psi>$ and $<\Phi|$.

(ii) Calculate $<\Phi|\psi>$ and $<\psi|\Phi>$. Are they equal

(b) Differentiate between degenerate and nondegenerate states.

(c) Show that exchange operator commutes with Hamiltonian. (8+4+8)

Section III

Q7.What are exactly and non-exactly solve able systems? Define the term perturbation and give detail description of time independent perturbation theory upto first order correction of energy and wave function? (20)

Q8. Estimate 1st excited state energy of one-dimensional harmonic oscillator using variational method. Given that

$$H = \frac{p^2}{2m} + \frac{1}{2}mw^2\bar{x}^2, \;\; \psi(x) = Axe^{-ax^2}$$ (20)

Q9. (a) Discuss pictures of quantum mechanics? Are they equivalent to each other?

(b) Use generalized uncertainty relation to obtain the uncertainty between E and t.

Where $E = i\hbar\frac{\partial}{\partial t}$ (10+10)

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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 different types of symmetry elements in each of the fourteen Bravais lattice (8.5)

(b) Calculate the interplanar spacing for (321) plane in simple cubic lattice with interatomic spacing a = 4.21 Å, also calculate interatomic spacing when interplanar spacing is (111). (4)

Q.2. (a) What do you mean by Brillouin Zone? Draw Wigner-Seitz unit cells for the following lattices: (i) An oblique lattice in two dimensions, (ii) a bcc lattice and (iii) an fcc lattice in three dimensions (6.5).

(b) Explain the structure factor of the fcc lattice and atomic form factor. (4)

Q:3 (a) Discuss X-ray diffraction in context of structural characterization. Define reciprocal lattice vectors, also link the condition for diffraction. (6.5)

(b) Determine the angle through which an X-ray of wavelength 1.540 Å be reflected from the cube face of NaCl (d = 2.814 Å) for first two order of reflection (4).

Q.4. ~~(a) Explain~~ elastic compliance and stiffness constants, also discuss elastic energy density, and stiffness constant of cubic crystals (8.5)

(b) Draw a region of first Brillouin zone, also define group velocity (4)

Section – II

Q. 5 (a) Discuss the advent of superconductivity and its occurrence at various temperatures. (3)

(b) What is Meissner effect? Classify type I and type II superconductors. (9.5)

Q. 6 (a) Describe the wave equation of electron in a periodic potential and the consequent restatement of Bloch theorem. (8.5)

(b) Define point defects and vacancies. (4)

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

i. Thermal conductivity of solids

ii. Paramagnetic susceptibility of conduction electrons

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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).** Derive the expression for ripple factor (γ) and V_{dc} in a π (pi) filter connected to a full wave bridge rectifier circuit.	10
	(b) Determine the ripple factor for a full-wave rectifier circuit with a π filter at 50 Hz frequency having; $C_1 = C_2 = 50\ \mu F$, $L = 5\ H$, $R_c = 200\ \Omega$, $I_{dc} = 300\ mA$ and V.	10
Q.2	**(a)** Determine the expression for current gain, voltage gain, power gain, input and output resistances, when a transistor is used as a common collector amplifier.	10
	(b) In C-C amplifier load resistance $R = 1500\ \Omega$, $h_{ie} = 1.8\ K\Omega$, $g_m = 0.018$ mho, h_{re} and h_{oe} are negligible. Find A_{vc}, A_{ic}, R_{ic} and P. G. (dB).	10
Q.3	**(a)** Draw the circuit and derive the expression for collector current and stabilizing ratio in a four resistors bias circuit.	10
	(b) Determine the design values of the resistances for the four resistor bias circuit with $V_{CC} = 20V$, $I_C = 6.7\ mA$ and $h_{fe} = 60$, using the usual circuit assumptions.	10
	Section II	
Q.4	**(a)** Why the gain of RC coupled amplifier reduces at low frequency?	2
	(b) Discuss the high frequency response of R-C coupled amplifier and determine $A_{v(hi)}$ and phase angle θ.	10
	(c) Define Miller's effect. Find out Miller input capacitance C_{in} for a transistor with $C_{be} = 36\ pF$, $C_{bc} = 4.0\ pF$, $h_{ie} = 950\ \Omega$, $h_{fe} = 190$ and $R_c = 1.2\ K\Omega$.	8
Q.5	**(a)** What are the differences between a BJT and JFET?	6
	(b) Explain the construction, draw the symbol and working of n-channel JFET with the help of its characteristics.	10
	(c) Why JFET cannot work in enhance mode?	4
Q.6	**(a)** Discuss the advantages and disadvantages of negative feedback.	8
	(b) How the gain of an amplifier can be stabilized by using negative feedback?	6
	(c) Using the block diagram of feedback we have $A = 50$, $\beta = 0.03$ and $V_o' = 5V$. Find V_S, V_i' and A'.	6
	Section III	
Q.7	**(a)** Write the conditions of sustained oscillation.	4
	(b) Draw the circuit, explain the working and find the relation for frequency of practical Colpitt oscillator.	10
	(c) In a Colpitt oscillator $C_1 = C_2 = C$, and $L = 150\ \mu H$. Find C when $f = 1.5$ MHz.	6
Q.8	**(a)** Explain the working of class B push-pull amplifier and find its maximum efficiency.	10
	(b) What is cross over distortion and how it is eliminated?	5
	(c) A transformer is mounted on an $8\ \Omega$ 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) Construction, symbol and working of zener and LED diodes.	
	(II) Darlington compound transistor.	10 + 10
	(III) Monostable multivibrator.	