Total No. of Printed Pages: 3

SUBJECT CODE NO: - FF-6564
FACULTY OF SCIENCE AND TECHNOLOGY
M.Sc. (Sem-I) (Physics)
Examination January-2023
Quantum Mechanics PHYC-113

[Time: 3:00 Hours] **[Max. Marks: 80]**

Please check whether you have got the right question paper.

N. B
1) Questions No.1 is compulsory and is multiple type It carries 20 marks
2) Attempt any four questions from Q.2 to Q.7 each of these questions carries 15 marks
3) Figures to the right indicates full marks.

Part –A

Q1 This is multiple choice questions write only the answer in your answer book 20

1) A system is subjected to a perturbation which lasts from the $t = 0\ to\ t = t_0$ and which is constant during this time the transition probability between the initial and final states
   a) Vanishes unless the initial and final energies are equal
   b) Is independent of t_o
   c) Is proportional to t_o and independent of the energies of the initial and final states.
   d) Can be finite event if the initial and final states have different energies

2) Transmission coefficient i.e T is defined as
   a) $T = \left|\frac{J_{transmitted}}{J_{incident}}\right|$ b) $T = \left|\frac{J_{incident}}{J_{transmitted}}\right|$
   c) $T = \left|\frac{J_{reflected}}{J_{incident}}\right|$ d) $T = \left|\frac{J_{incident}}{J_{reflected}}\right|$

3) Eigen value equation of $\hat{L}_+$ is
   a) $\hbar\sqrt{2l\,(l+1) - m(m+1)}$ b) $\hbar\sqrt{l(l+1) - 2m(m+1)}$
   c) $\hbar\sqrt{l(l-1) - m(m+1)}$ d) $\hbar\sqrt{l(l+1) - m(m+1)}$

4) Pauli matrix σ_x is
   a) $\begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}$ b) $\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$ c) $\begin{pmatrix} i & 0 \\ 0 & -i \end{pmatrix}$ d) $\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$

5) According to the WKB approximation in case of system moving in a potential with no rigid wall

a) $\oint pdx = 2\pi\hbar$ b) $\oint pdx = 2\left(n+\frac{3}{4}\right)h$

c) $\oint pdx = n\hbar$ d)$\oint pds = \left(n-\frac{1}{2}\right)h$

6) If hydrogen atom is kept in an external electric field E, then first order change In E will be

a) Zero b) $E_0 + E$ c) $E + E^2$ d) none of these

7) According to the scattering theory incoming and outgoing waves are approximated as respectively

a) Constant and plane b) spherical and plane

c) plane and spherical d) plane and constant

8) Dirac predicted the existence of

a) Relativity b) positron c) electron d) Bosson

9) For rigid sphere of radius a the scattering cross section at low energies is given as

a) $4\pi a^2$ b) $2\pi a^2$ c) πa^2 d) $3\pi a^2$

10) The wave $\psi = Ae^{ikx}$ propagates in the direction of

a) Negative x-axes b) positive y-axes c) positive x –axes d) none of these

Part –B

Attempt any four

Q2 a) Obtain the exact solution of schrodinger equation in 1-D. 8

b) Explain the terms 7

i) Tunnelling ii) ladder operator

Q3 a) Show that 8

i) $\sigma_y^2 = \hat{I}$ ii) $\sigma_x\sigma_y\sigma_z = i\hat{I}$ where σ_k where k=x or y or z are pauli mitrices

b) Explain stern –Gerlach experiment 7

Q4 a) A system is acted upon by an external time dependent perturbation derive an expression for transition probability. 8

	b)	Explain Variational principle with example	7
Q5	a)	Obtain an expression for scattering amplitude for the scattering of the electron by coulomb potential.	8
	b)	Discuss in detail Born approximation outline in brief its validity	7
Q6	a)	Derive a variation function for a particle confined to a box of length l. find the energy of the particle using the variational principle.	8
	b)	State sudden and adiabatic approximation.	7
Q7	a)	What is a differential scattering cross section. Obtain equation for differential scattering cross section.	8
	b)	Obtain eigen value equation for i) $\vec{L}^2$ ii) $\vec{L}_z$	7

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SUBJECT CODE NO: - FF-6608
FACULTY OF SCIENCE AND TECHNOLOGY
M.Sc. (Sem-I) (Physics)
Examination January-2023
Statistical Mechanics PHYC-114

[Time: 3:00 Hours] **[Max. Marks:80]**

Please check whether you have got the right question paper.

N. B
1. Question 1 is compulsory; it carries 20 marks.
2. Attempt any four questions from Q.2 to Q.8. Each of these questions carries 15 marks.
3. Figures to the right indicate full marks.

Part A

Q1 This is a multiple choice question. 20
Write only the answer in your answer book.

1. Fermions have _____ wave functions
   a. Zero b. symmetric c. antisymmetric d. complex

2. Particles with ____ spin integral momentum can not be treated as Fermions.
   a. $\frac{3\hbar}{2}$ b. $\frac{4\hbar}{2}$ c. $\frac{\hbar}{2}$ d. $\frac{5\hbar}{2}$

3. Bose condensate heat capacity varies as _____
   a. $T^{2}/_{3}$ b. $T^{3}/_{2}$ c. T d. T^{-1}

4. A black body radiates at 1 kW when its temperature in boo, when its temperature is 1000k, it radiates _____
   a. 2 KW b. $\frac{1}{16}KW$ c. 16 KW d. 4 KW

5. Intrinsic carrier concentration at temperature T depends on ____ energy only.
   a. CB mid gap b. Fermi c. midgap d. VB

6. If the bottom of CB is at 8ev, top of VB is at 5ev, them mid gap energy will be _____ ev.
   a. 3 b. 1.5 c. 4 d. 6.5

7. If V_H is the Hall voltage, t is the thickness of a current I carrying conductor in placed in an external magnetic field B, the isothermal Hall coefficient R_H is given by _____
   a. V_H t I_B b. $V^2{}_{Ht}$ I_B c. $\frac{V_H^2 t}{I_B}$ d. $\frac{V_H\, t}{I_B}$

8. A quadrivalent intrinsic semiconductor is doped by a trivalent impurity, Resultant semiconductor will be _____
   a. Metal b. n c. n or p d. p

9. If E_F-$E_{midgap} = \frac{3}{4}\ln\left(\frac{m_p^*}{m_n^*}\right)$ and is $m_p^* < m_n^*$ then _____
   a. Ep will Lie below E midgap
   b. E_F will Lie above Emidgap
   c. E_F= E midgap
   d. $E_F = \frac{1}{2}$ E midgap

10. If n = con centration, e = charge and μ= mobility then the electrical
    a. $\frac{e}{\mu n}$ b. $\frac{\mu}{ne}$ c. μne d. $\frac{n}{\mu e}$

Part B

Q2 a. Derive an expression for average energy of electrons at 0 K. 8
b. Calculate the Fermi-Energy and velocity of electrons at the Fermi level in copper if the density of copper is 8.96 gm/cm^3 and atomic weight is 63.5 gm/mole. $[h = 6.626 * 10^{-34}\ JS;\ \hbar = 1.055 * 10^{-34}\ JS; m_e = 9.20 * 10^{-31} kg, 1\ ev = 1.602 * 10^{23}$ atomsl mole] is the velocity relativistic? 7

Q3 a. Derive an expression for the critical temperature T_c for a BE condensation as a function of the number density? 8
b. A German sample is doped with an acceptor impurity concentration of 10^{15} atoms / cm^3. If hole mobility is 1800 cm^2 / v-s, calculate resistivity. 7

Q4 a. Discuss equilibrium of free electron in semiconductors – Non degenerate case. 8
b. Three volts are applied across a 1 cm long semiconductor bar. The average electron drift velocity is 10^4cm/s. find the electron mobility if the electron mobility in above said bar were 800 cm^2 / V-s, what is the average electron drift velocity? 7
Mobility =drift velocity/electric field

Q5 a. Derive Boltzmann Transport Equation Explain different terms. 8
b. AT T=300k in a certain material the electron concentration varies linearly form $1 * 10^{18}\ cm^{-3}\ to\ 7 * 10^{17}\ cm^{-3}$ over a distance of 0.10 cm. calculate the diffusion current density if the electron diffusion coefficient $D_n = 225\ cm^2/s$ 7

Q6 a. Explain magnetic susceptibility of free electron. 8
b. Calculate the ionization energy of a donor impurity in Ge. The effctive mass of electrons $m_e^* = 0.12\ M_o$ and the dielectric constant k =16. 7
[you may use formula: Ionization energy = $\frac{m_e^* e^3}{8\,h^2 k^2 \varepsilon_0^2}$ ev . h=6.626 * 10^{-34} JS, $\varepsilon_0 = 8.854 * 10^{-12}\ F/m$)

Q7 a. Calculate the energy levels in sodium (E_F=3.13ev) for which the probabilities of occupation of electrons at 300k are 0.25, 0.5 and 0.75. 8

b. Explain Landau theory-Tisza two fluid model. 7

Q8 a. Write down Boltzmann transport equation. From this, obtain expression for the particle flux density. 8

b. Copper has an outer electronic configuration of $3d^{10}4S'$. It is density =8.96 gm/cm^3 and an atomic weight = 63.5 gm/mole. Calculate the Fermi energy of electrons in copper. [Avogadro number =6.023 * 10^{23} atoms/mole, $\hbar = 1.055 * 10^{-34} JS, m_e = 9.20x10^{-31} kg \; and \; 1ev = 1.602 * 10^{-19}$J] 7

Total No. of Printed Pages: 2

SUBJECT CODE NO: - FF-6675
FACULTY OF SCIENCE AND TECHNOLOGY
M.Sc. (Sem-I) (Physics)
Examination January-2023
Research Methodology PHYF-115

[Time: 2:00 Hours] **[Max. Marks: 40]**

Please check whether you have got the right question paper.

N. B
(i) Question no. 1 is multiple choice objective type and it is compulsory. It carries 10 Marks.
(ii) Attempt any FIVE questions from Q. No. 2 to Q. No. 8. Each of these questions carries 06 Marks.
(iii) Figures to the right indicates full marks.

Q1 Attempt all MCQs. (10)

(i) What is KAIZEN?

A) Japanese Business philosophy of continuous improvement
B) Indian Academic philosophy of continuous improvement
C) Japanese Academic philosophy of continuous improvement
D) All of the above

(ii) What make people to undertake research?

A) To get research degree
B) Service to the society
C) Face the challenges in solving unsolved problems
D) All of the above

(iii) Which is cite score of a research journal?

A) It is the result of citations of the journal for last two years
B) It is the result of citations of the journal for last three years
C) It is the result of citations of the journal for last four years
D) It is the result of citations of the journal for last five years

(iv) _____ is a hypothesis that says there is no statistical significance between two variables in the hypothesis.

A) Null hypothesis

B) Casual hypothesis

C) Analytical hypothesis

D) All of the above

(v) Research always _____.

A) Explore new knowledge

B) Verify old knowledge

C) Fill gaps between the knowledge

D) All of the above

Q2 What are sequential steps to be followed by researchers to identify research problem? (06)
Explain in brief (Each step)

Q3 What are the challenges while doing research? (06)
Explain in brief (Each of the challenges)

Q4 What is Literature review? Explain the purpose of Literature review. (06)

Q5 Explain Null hypothesis and alternate hypothesis with examples. (06)

Q6 What is the Outline Manuscript of research paper? (06)
Explain each step in brief

Q7 What is overall organization of Research proposal? (06)
Explain it in brief

Q8 What are types of Research Report? (06)
Explain each in brief

Total No. of Printed Pages: 3

SUBJECT CODE NO: - FF-6501
FACULTY OF SCIENCE AND TECHNOLOGY
M.Sc. (Sem-I) (Physics)
Examination January-2023
Mathematical Methods in Physics -PHYC-111

[Time: 3:00 Hours] **[Max. Marks: 80]**

Please check whether you have got the right question paper.

N. B
1. Q.No.1 is compulsory. It carries 20 marks.
2. Attempt any four questions from Q.2 to Q.8. Each of these questions carries 15 marks.
3. Figures to the right indicate full marks.

PART A

Q1 This is a multiple choice question. 20

1) If the Fourier series $f(x) = \tan x = \tan(x + 3\pi) = \tan(x + 6\pi) =$ ----- then the period of the series is --------
   a) 0 b) π c) 3π d) 6π

2) The Fourier series $f(x) = x - x^2 for - \pi < x < \pi$, the coefficient $\frac{a_0}{2}$ =--------
   a) π b) $\frac{\pi^2}{3}$ c) $\frac{2\pi^2}{3}$ d) $\frac{-\pi^2}{3}$

3) For the Fourier series $f(x) = \begin{cases} 0, & for -5 < x < 0 \\ 3, & for\ 0 < x < 5 \end{cases}$, the coefficient $\frac{a_0}{2}$ =-------
   a) 3 b) 5/2 c) 5 d) 3/2

4) The series of the ---------- function will contain only cosine term
   a) Odd b) even c) any d) only a & b

5) For odd function, the area under the curve from $-\pi$ to π is ----------
   a) Zero b) double c) half d) independent

6) The Fourier sine transform of $\frac{1}{x}$ = --------
   a) $\sqrt{\pi}$ b) $\sqrt{\frac{2}{\pi}}$ c) $\sqrt{\frac{\pi}{2}}$ d) $\sqrt{\frac{4}{\pi}}$

7) The value of $\oint_c \frac{1}{z^2+4}\, dz$ =---------- [at pole z=2i, where c is circle $|z + 3i| = 2$]
   a) π b) 0 c) $\frac{\pi}{2}$ d) $\frac{-\pi}{2}$

8) The Residue at z=i of $\frac{1}{z^2}(z-i)$ =-------

a) 0 b) -1 c) 1 d) none of the above

9) $L[t\sin 2t]$ =-------

a) $\frac{4s}{(s^2+4)^2}$ b) $\frac{4}{(s^2+4)^2}$ c) $\frac{4s}{s^2+4}$ d) $\frac{4s}{(s^2-4)^2}$

10) Poles of the integral $\int_c \frac{1}{z^2+7}\,dz$ =-------

a) 7, 7 b) -7, -7 c) -7i, -7i d) 7i, -7i

PART B

Attempt any four

Q2 a) Obtain Fourier series of function $f(x) = x\sin x$ in the interval $-\pi < x < \pi$ 07

b) Find Fourier series of $f(x) = x + x^2$ in the interval $-\pi < x < \pi$ and show that $\frac{\pi^2}{6} = \sum_{n=1}^{\infty}\frac{1}{n^2} = 1 + \frac{1}{2^2} + \frac{1}{3^2} +$------- 08

Q3 a) Define Fourier transform. Find the Fourier cosine transform of $e^{-2x} + 4e^{-3x}$ 07

b) Convert the time domain data into frequency domain of triangular pulse 08

$$f(f) = \begin{cases} t+1, -1 \le t \le 0 \\ -t+1,\ 0 < t \le 1 \end{cases}$$

Q4 a) Define Laplace transform. Find the Laplace transform of $\sin^3 2t$ 07

b) Express the following function in terms of unit step function and find its Laplace transform. 08

Q5 a) By using Cauchy integral formula, find the value of $\int_c \frac{2z^2+z}{z^2-1}\,dz\,, c: |z| = 1$ 07

b) Solve using Residue calculus $\int_0^{\pi}\frac{d\theta}{17-8\cos\theta}$ 08

Q6 a) If $f(x) = x^2 for -\pi \le x \le \pi$, find the Fourier series expansion, hence find the sum of series $\frac{1}{1^2} - \frac{1}{2^2} + \frac{1}{3^2} - \frac{1}{4^2} +$-------- 07

b) Find the Fourier cosine transform of $f(x) = \begin{cases} \cos x, & 0 < x < a \\ 0, & x > a \end{cases}$ 08

Q7 a) Solve the initial value problem $y'' + y = \sin 3t$ with values $y(0) = 0, y'(0) = 0$ 07

b) In the Region R, find the derivative of function and show that it is constant throughout the region R. $f(z) = (3x + y) + i(-x + 3y)$ 08

Q8 a) Define Fourier series. Find the Fourier series representing $f(x) = x^3$ in between $-\pi \leq x \leq \pi$ 07

b) Find the Laplace transform of $t^2 \cos at$ 08

Total No. of Printed Pages: 2

SUBJECT CODE NO: - FF-6529
FACULTY OF SCIENCE AND TECHNOLOGY
M.Sc. (Sem-I) (Physics)
Examination January-2023
Classical Mechanics – PHYC-112

[Time:3.00 Hours] **[Max. Marks:80]**

Please check whether you have got the right question paper.

N. B
1) Question one is compulsory. It carries 20 marks.
2) Attempt any four questions from 2 to 8, each carry 15 marks.
3) Figure to the right indicates full marks.

Part A

Q1 (i) The degree of freedom of spring pendulum is _____ in cartesian co-ordinate. 02
a) 1 b) 2 c) 3 d) 4

(ii) A particle is moving on the surface of cone, the generalized co-ordinate of this system is _____. 02
a) x b) μ, θ c) $\mu, \theta, \emptyset$ d) x, y, z

(iii) The Hamiltonian equation of motion are _____ order differential equations. 02
a) First b) Second c) zero d) Fourth

(iv) The total linear momentum of a closed system is conserved due to homogeneity of the _____. 02
a) Space b) Time c) Momentum d) None of the above

(v) The Hamiltonian corresponding to Lagrangian $L = ax^2 + by^2 - kxy^2$ is 02
a) $\frac{Px^2}{2a} + \frac{Py^2}{2b} + kxy$ b) $\frac{Px^2}{4a} + \frac{Py^2}{4b} - kxy$
c) $\frac{Px^2}{4a} + \frac{Py^2}{4b} + kxy$ d) $\frac{Px^2}{4ab} + \frac{Py^2}{4ab} + kxy$

(vi) If a planet sweeps equal area in equal interval of time, then orbit will be 02
a) Parabolic b) elliptical c) hyperbolic d) triangular

(vii) When "e" is eccentricity and "E" is energy, then condition for elliptical orbit is _____ 02
a) E>0, e=1 b) E<0, e=1 c) E>0, e=0 d) E<0, e<1

(viii) The value of Poisson's Bracket $[x^2, Px^2]$ is 02
a) $4x^2$ b) $4Px^2$ c) $4xPx$ d) xpx.

(ix) Coriolis force is a ____ force. 02
a) Real b) pseudo c) gravitational type d) $\frac{1}{\mu}$ type

(x) The magnitude of Coriolis force at equator is _____ 02
a) Negative b) zero c) imaginary d) none of the above

Part B

Q2 Derive the Lagrangian equation for a conservation system. 15

Q3 (i) Show that the shortest distance between two points in a plane is a straight line. 07
(ii) State and explain configuration space, phase space & state space. 08

Q4 (i) State Kepler's law. Deduce first law. 10
(ii) Show that Poisson bracket of 2 dynamic variables is invariant under canonical transformation. 05

Q5 (i) How are velocities & acceleration related to each other if one of the two frames is inertial while other is rotating. 10
(ii) Explain Coriolis force. 05

Q6 (i) A linear transformation of a generalised co-ordination 'q' and the corresponding momentum 'p' is $Q = q + p, P = q + \propto p$ is canonical. Find the value of $\propto$. 08
(ii) Find the Lagrangian for spring pendulum system. (Spring has length l, spring constant K and mass of bob is mn) 07

Q7 Explain the following.
(i) Constraints 05
(ii) Generating function 05
(iii) Cyclic co-ordinates 05

Q8 Write down the difference between holonomic – non holonomic, rheonomic – scleronomic , and conservative – non-conservative constraints. 15