Seat No. : _____

# FA-136

**February-2025**

**M.Sc., Sem.-I**

**PHY-401 : Physics**

**(Quantum Mechanics-I and Mathematical Physics – I)**

**(NEW)**

**Time : 2:30 Hour]** **[Max. Marks : 70**

**Section – I**

1. (A) Obtain an expression for the first ionization potential $V_{ion}$ for a two-electron atom. **7**

   (B) Discuss Upper Bound on Ground State Energy using the Variation method. **7**

**OR**

1. (A) What do you mean by perturbation ? Obtain $1^{st}$ order and $2^{nd}$ order equations of perturbation theory. **7**

   (B) Solve the $1^{st}$ order equation of perturbation theory if eigen value is non-degenerate. **7**

2. (A) Obtain an expression for the co-efficients $C_n(0)$ in the time dependent part of Schrodinger equation. **7**

   (B) Discuss propagators and obtain an expression for the Green's function $G_R$. **7**

**OR**

2. (A) Using WKB approximation method, obtain asymptotic solution of Schrodinger equation. **7**

   (B) Prove that in sudden approximation, the transition amplitude $C_{fi}$ is proportional to the matrix element of the change in the Hamiltonian and to the time for which this change persists. **7**

3. (A) Write statement of Morera's theorem and show that if function f(Z) is analytic within an on closed curve C, then **7**

$$\oint f(Z)dZ = 0$$

   (B) Evaluate integral $I = \int_0^{2\pi} \frac{\cos 3\theta}{5 - 4\cos\theta} d\theta$ by using Residue theorem. **7**

**OR**

3. (A) Explain terms; Singularity, Pole and Simple pole. Using a simple pole method solve following : **7**

(i) If $f(Z) = \frac{z}{(2z + 1)(5 - z)}$, find R $(-\frac{1}{2})$, and R(5).

(ii) If $f(Z) = \frac{\cos z}{z}$, find R(0)

(B) Using Cauchy-Riemann's conditions find out given functions are analytic or non-analytic. **7**

(i) $f(Z) = \frac{z}{(z^2 + 1)}$

(ii) $f(Z) = (z^2 - \bar{z}^2)$

4. (A) Define groups, subgroups and classes. Discuss four properties of a group with examples. **7**

(B) Give definition of a Tensor in 3D space and discuss various properties of tensors with examples. **7**

**OR**

4. (A) Discuss – invariant subgroups, factor groups, Homomorphism and Isomorphism. **7**

(B) (i) Show that addition and substraction of two tensors leads to new tensors of same rank and same size. **7**

(ii) Obtain the matrix for spherical co-ordinates and cylindrical co-ordinates.

## Section – II

5. Attempt any **seven** questions. Each question carries **two** marks. **14**

(1) The matrix element of Hamiltonian H' between states $U_k$ and $U_m$ is represented by integral equation _____.

(2) If the eigen value $E_m$ of Hamiltonian is 4 fold-degenerate then, the eigen space of $v^{(0)}$ is spanned by set of eigen functions _____.

(3) In the expression $v = (1 + \lambda Cm^{(1)})um + \Sigma' \lambda Cm^{(1)}un$ the prime on summation sign ($\Sigma'$) represents that _____.

(4) The retarded Green's function $G_R(\vec{X}, \vec{X}' ; t, t')$ depends only on _____.

(5) If the probability of finding an electron in a state is 0.25, then the amplitude A for an electron to be found in such a state should be _____.

(6) The differentiation of Heaviside unit function with respect to time is $d\theta(t)/dt$ = _____.

(7) What is a *Cyclic* group ? Give an example of a *Cyclic* group.

(8) Prepare group table of three elements E, A, B.

(9) Write two properties of Dirac-delta function.

(10) Find out real and imaginary parts of f(Z) = sin z, where Z= x+iy.

(11) Define Levi-Civeta symbol in 4-dimensional space.

(12) Define a dummy tensor and fundamental tensor.

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**OR**

1. (A) What do you mean by perturbation ? Obtain 1st order and 2nd order equations of perturbation theory. **7**

   (B) Solve the 1st order equation of perturbation theory if eigen value is non-degenerate. **7**

2. (A) Obtain an expression for the co-efficients $C_n(0)$ in the time dependent part of Schrodinger equation. **7**

   (B) Discuss propagators and obtain an expression for the Green's function $G_R$. **7**

**OR**

2. (A) Using WKB approximation method, obtain asymptotic solution of Schrodinger equation. **7**

   (B) Prove that in sudden approximation, the transition amplitude $C_{fi}$ is proportional to the matrix element of the change in the Hamiltonian and to the time for which this change persists. **7**

3. (A) Solve the Bessel's equation with n = 0, using a Laplace transform : **7**

   $x^2\, y''(x) + xy'(x) + x^2\, y(x) = 0.$

   Initial conditions are : $y(+0) = 1,\ y'(+0) = 0.$

   Given : $\mathcal{L}\{t^n\} = n!s^{n+1} \quad s > 0, \quad n > -1.$

   (B) Prove that $\mathcal{L}\left\{\dfrac{\cos at - \cos bt}{b^2 - a^2}\right\} = \dfrac{s}{(s^2 + a^2)(s^2 + b^2)}$, where $a^2 \neq b^2$ **7**

**OR**

3. (A) Solve following differential equation using a Laplace transform : **7**
y" + 2y′+ 2y = 0, with initial conditions y(0) = –1, y′(0) = 2 and y is a function of time t.

(B) Solve the differential equation for a damped harmonic oscillator **7**
mX"(t) + bX′(t) + kX(t) = 0, for $b^2 < 4km$,
with initial conditions $X(0) = X_0$, X' (0) = 0.

Given : $\mathcal{L}\{e^{-at} \cos bt\} = \frac{(s + a)}{(s + a)^2 + b^2}$

$\mathcal{L}\{e^{-at} \sin bt\} = \frac{(b)}{(s + a)^2 + b^2}$

4. (A) Define groups, subgroups and classes. Discuss four properties of a group with examples. **7**

(B) Give definition of a 'Tensor' in 3D space and discuss various properties of tensors with examples. **7**

**OR**

4. (A) Discuss invariant subgroups, factor groups, Homomorphism and Isomorphism. **7**

(B) (i) Show that addition and substraction of two tensors leads to new tensors of same rank and same size. **7**

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(4) The retarded Green's Junction $G_R(\vec{X}, \vec{X}' ; t, t')$ depends only on _____.

(5) If the probability of finding an electron in a state is 0.25, then the amplitude A for an electron to be found in such a state should be _____.

(6) The differentiation of Heaviside unit function with respect to time is $d\theta(t)/dt$ = _____.

(7) What is the Laplace transform of t ?

(8) $\mathcal{L}\{\cos kt\}$= _____.

(9) An inverse Laplace of 1 = _____

(10) Prepare a group table of three elements E, A, B.

(11) Define Levi-Civeta symbol in 4-dimensional space.

(12) Define a dummy tensor and a fundamental tensor.

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