2017

(5th Semester)

PHYSICS

FIFTH PAPER

(Mathematical Physics—I)

(Pre-Revised)

Full Marks : 75

Time : 3 hours

(PART : B—DESCRIPTIVE)

(*Marks* : 50)

The figures in the margin indicate full marks for the questions

1. *(a)* What do you mean by singular point of a differential equation? Find the singular points for the following differential equations : 3

(i) $(x \quad 5)y \quad (x \quad 1)y \quad 0$

(ii) $(x^2 \quad 1)y \quad y \quad x^2 y \quad 0$

(b) Using Frobenius method, find the series solution about $x \quad 0$ of $x(x \quad 1)y \quad 3xy \quad y \quad 0$. 7

Or

(c) Show that the solution of the partial differential equation of heat flow in one-dimension with initial conditions $u(x, 0) \quad \cos 2x$ is $u(x, t) \quad \exp(\ 4t)\cos 2x$, where $u(x, t)$ is the temperature distribution function. 8

(d) Write down two-dimensional Laplace's equation in both Cartesian and Polar coordinates defining the symbols (coordinate variables) used in the equations. 2

2. *(a)* Prove the following recursion relations for Legendre polynomials : 7

(i) $nP_n(x) \quad (2n \quad 1)xP_{n \quad 1}(x) \quad (n \quad 1)P_{n \quad 2}(x)$

(ii) $nP_n(x) \quad xP_n(x) \quad P_{n \quad 1}(x)$

(b) For Hermite's polynomial $H_n(x)$, show that $2xH_n(x) \quad 2nH_{n \quad 1}(x) \quad H_{n \quad 1}(x)$ for $n \quad 1$. 3

Or

(c) Prove the following : 4

(i) $H_{2n}(0) \quad (\ 1)^n \frac{(2n)!}{n!}$

(ii) $H_{2n \quad 1}(0) \quad 0$

(d) Show that

$$J_{3/2}(x) \quad \sqrt{\frac{2}{x}} \ \frac{\sin x}{x} \quad \cos x$$ 6

3. *(a)* Write down Cauchy-Riemann conditions for the analyticity of a function of complex variables. Find out whether or not the function $f(z)$ u iv with $u(x, y)$ x^2 y^2 and $v(x, y)$ $2xy$ satisfy Cauchy-Riemann equations. 4

(b) Use residue theorem to evaluate the integral

$$\frac{dx}{x^2 \quad 2x \quad 2}$$ 6

Or

(c) Find the Laurent series expansion of $f(z)$ $\frac{2z^3 \quad 1}{z^2 \quad z}$ about z 1. 5

(d) What do you mean by singularity? Find the location of singularities of the following : 5

(i) $\frac{1}{\cos z \quad \sin z}$

(ii) $\frac{1}{1 \quad e^z}$

4. *(a)* What do you understand by orthogonal curvilinear coordinate system? Deduce the expression for the gradient of a scalar field in general orthogonal curvilinear coordinate system. 1+5=6

(b) A central force field is given by

$$\vec{F} \quad \hat{e}_r \frac{2r_o \cos}{r^3} \quad \hat{e} \quad \frac{r_o}{r^3} \sin$$

Calculate $\vec{} \quad \vec{F}$. 4

Or

(c) What are covariant, contravariant and mixed tensors? Show that Kronecker delta is a mixed tensor of rank 2. 2+2=4

(d) If $a \quad x \quad x \quad 0$ for all values of the variables $x^1, x^2, \cdots, x^N$. Show that $a_{ij} \quad a_{ji} \quad 0$. 3

(e) If A and B are tensors, then prove that their sum and difference are also tensors of the same type. 3

5. *(a)* Show that every square matrix can be uniquely expressed as a sum of a symmetric and a skew-symmetric matrices. 3

(b) What is unitary matrix? Show that the matrix

$$\begin{matrix} 0 & i \\ i & 0 \end{matrix}$$

is unitary. 3

(c) Show that any two eigenvectors corresponding to two distinct eigenvalues of a Hermitian matrix are orthogonal. 4

Or

(d) Find the eigenvalues and eigenvectors of the matrix

$$\begin{pmatrix} \cos & \sin \\ \sin & \cos \end{pmatrix}$$ 5

(e) Diagonalize the matrix

$$\begin{pmatrix} \cos & \sin & 0 \\ \sin & \cos & 0 \\ 0 & 0 & 1 \end{pmatrix}$$ 5

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Subject Code : PHY/V/05 (PR)

Booklet No. A

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To be filled in by the Candidate

DEGREE 5th Semester
(Arts / Science / Commerce / .....) Exam., **2017**

Subject .....

Paper .....

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DEGREE 5th Semester
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Roll No. .....

Regn. No. .....

Subject .....

Paper .....

Descriptive Type

Booklet No. B .....

Signature of Scrutiniser(s)

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Signature of Invigilator(s)

/207

2 0 1 7

(5th Semester)

PHYSICS

FIFTH PAPER

(Mathematical Physics—I)

(Pre-Revised)

(PART : A—OBJECTIVE)

(*Marks* : 25)

The figures in the margin indicate full marks for the questions

SECTION—I

(*Marks* : 10)

Put a Tick ☑ mark against the correct answer in the box provided : 1×10=10

1. Which of the following is a wave equation?

(a) $\frac{^2u}{x^2}$ $c^2\frac{^2u}{t^2}$ ☐

(b) $\frac{^2u}{x^2}$ $\frac{1}{c^2}\frac{^2u}{t^2}$ ☐

(c) $\frac{u}{t}$ $c^2\frac{^2u}{x^2}$ ☐

(d) ^2u k^2u 0 ☐

2. The solution of the differential equation $y \quad e^{2x}$ is

(a) $y \quad e^{x} \quad c$ ☐

(b) $y \quad e^{2x} \quad c$ ☐

(c) $y \quad \frac{e^{2x}}{2} \quad c$ ☐

(d) $y \quad e^{2x} \quad 4$ ☐

3. The value of $\int_{1}^{1}(2x \quad 1)P_3(x)\,dx$ is

(a) 1 ☐

(b) –1 ☐

(c) 2 ☐

(d) 0 ☐

4. The value of $\frac{J_{1/2}(x)}{J_{\ 1/2}(x)}$ is

(a) 1 ☐

(b) $\tan x$ ☐

(c) $\cot x$ ☐

(d) $\tanh x$ ☐

5. The order of the pole of the function $f(z)$ $\dfrac{z^4 \quad 2z \quad 1}{z^2 \quad 5z \quad 1}$ at z is

(a) 2 ☐

(b) 1 ☐

(c) 0 ☐

(d) 4 ☐

6. The value of the integral $\int_C \tan z \, dz$, where C is $|z|$ 2 is

(a) 0 ☐

(b) i ☐

(c) 2 i ☐

(d) $\frac{}{2}$ ☐

7. In three-dimensional Cartesian system, the value of dirac delta function $_{ii}$ is

(a) 0 ☐

(b) 1 ☐

(c) 2 ☐

(d) 3 ☐

8. In spherical coordinate system $(r, \ , \ )$, the intersection between coordinate surfaces $r \quad c_1$ and c_2 is

(a) a straight line ☐

(b) a circle ☐

(c) a semicircle ☐

(d) an ellipse ☐

9. If $A^T A \quad I$, the square matrix A is called

(a) Hermitian matrix ☐

(b) unitary matrix ☐

(c) orthogonal matrix ☐

(d) symmetric matrix ☐

10. For the Hermitian matrices A and B,

(a) $(AB)^\dagger \quad B^\dagger A^\dagger$ ☐

(b) $(AB)^\dagger \quad A^\dagger B^\dagger$ ☐

(c) $(AB)^T \quad B^T A^T$ ☐

(d) $A^\dagger A \quad B^\dagger B$ ☐

SECTION—II

(*Marks* : 15)

Write short answers to the following questions : 3×5=15

1. Explain the difference between an ordinary differential equation and a partial differential equation. Give examples.

2. Using the recursion relation,

$$\frac{d}{dx}[x^n J_n(x)] \quad x^n J_{n\ 1}(x)$$

show that

$$\int_0^x x^n J_{n\ 1}(x)\, dx \quad x^n J_n(x)$$

3. Test the analyticity of $|z|$, where $z \quad x \quad iy$.

4. Write the coordinate transformation relations for the following tensors :

(i) A_l^k

(ii) A_k^{ij}

5. If H is a Hermitian matrix, show that e^{iH} is unitary matrix.

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2017

(5th Semester)

PHYSICS

FIFTH PAPER

(Mathematical Physics—I)

(Revised)

Full Marks : 75

Time : 3 hours

(PART : B—DESCRIPTIVE)

(*Marks* : 50)

The figures in the margin indicate full marks for the questions

1. *(a)* Show that beta function obeys the following identities : 2+2=4

(i) $(m \quad 1, n \quad 1) \quad \frac{n}{m \quad 1} \quad (m, n)$

(ii) $(m \quad 1, n) \quad (m, n \quad 1) \quad (m, n)$

(b) Prove that

$$\int_0^{/2} \sin^p \quad \cos^q \quad d \quad \frac{\frac{p \quad 1}{2} \quad \frac{q \quad 1}{2}}{2 \quad \frac{p \quad q \quad 2}{2}}$$

Hence show that

$$\int_0^{/2} \sin^3 \quad d \quad \int_0^{/2} \cos^3 \quad d \quad \frac{2}{3} \qquad 4+2=6$$

Or

(a) Using the definition of gamma function, find the value of $(\frac{1}{2})$. 4

(b) Show that

(i) $\int_0 e^{\ x^2} dx \quad \frac{\sqrt{\ }}{2}$

(ii) $\int_0^{/2} \cos^{2m \ 1} \quad \sin^{2n \ 1} \quad d \quad \frac{(m, n)}{2}$

3+3=6

2. *(a)* Let $z \quad x \quad iy$ be a complex number. Show that $f(z) \quad z^2$ is analytic function but $f(z) \quad z^{\ 1}$ is not an analytic function. 2+2=4

(b) State Cauchy's residue theorem. Use this theorem to show that

$$\oint_C \frac{\sin 2z}{z \quad \frac{}{4}^3} dz \quad 4 \ i$$

where circle C is defined by $|z| \quad 2$. 1+5=6

Or

(a) State and prove Cauchy's integral formula. 1+3=4

(b) Use Cauchy's integral formula to evaluate the integrals : 3+3=6

(i) $\oint_C \frac{dz}{z^2 \quad z}$, where C is a circle defined by $|z| \quad 1$

(ii) $\oint_C \frac{2 \quad z}{z(2 \quad z)}\, dz$, where circle C is $|z| \quad 1$

3. *(a)* Find the inverse of the matrix

$$A \quad \begin{matrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{matrix}$$ 4

(b) Show that the eigenvalues of a Hermitian matrix are real. 3

(c) Show that the matrix

$$\begin{matrix} 0 & i \\ i & 0 \end{matrix}$$

is unitary. Find its eigenvalues. 2+1=3

Or

(a) For a matrix

$$A \quad \begin{matrix} 1 & 2 \\ 3 & 5 \end{matrix}$$

show that A (adj A) (adj A) $A \quad |A| I_n$. 3

(b) Show that any square matrix A can be uniquely expressed as $H_1 \quad iH_2$, where H_1 and H_2 are both Hermitian matrices. What are the expressions for H_1 and H_2? 1+2=3

(c) Solve the following simultaneous equations by matrix method : 4

$$\begin{matrix} 2x & 3y & 4z & 9 \\ & 2y & 3z & 8 \\ & x & z & 3 \end{matrix}$$

4. *(a)* In plane polar coordinates, show that the unit vectors are given by $\hat{r} \quad \hat{i}\cos \quad \hat{j}\sin$ and $\hat{} \quad \hat{i}\sin \quad \hat{j}\cos$. 3

(b) Find the scale factors in orthogonal curvilinear coordinate system. Hence obtain scale factors in Cartesian and cylindrical coordinate systems. 2+2=4

(c) Show that the cylindrical coordinate system is orthogonal. 3

Or

(a) By writing their transformation relations, explain what you mean by covariant and contravariant vectors. Give one example of each. 2+2=4

(b) Show that Kronecker delta δ^i_j is a mixed tensor of rank 2. 3

(c) If a contravariant tensor of rank 2 is symmetric in one coordinate system, show that it is symmetric in any other coordinate system. 3

5. *(a)* With the help of appropriate flowchart diagram, describe how 'while', 'do while' and 'for' loop control statements are executed in C++ programs. 5

(b) Write a C++ program to find the sum of the first N natural numbers and print the result. Use either 'for' loop or 'do while' loop. 3

(c) What are the values of a and b in the following C++ program segment? 2

```
int a, b;
a  5 / 3  6;
b  6  5 / 3;
```


Or

(a) Discuss one-dimensional and two-dimensional arrays in C++ with examples. How are character strings arranged in array? 3

(b) Write a C++ program for displaying a (3 3) matrix using an array. Input the elements rowwise and print the matrix in a (3 3) matrix form. 5

(c) What are the values of x and y at the end of the following C++ program segment? 2

```
int x  10, y  20;
x  x  y;
y  x  y;
x  x  y;
```

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Subject Code : PHY/V/05 (R)

Booklet No. A

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Regn. No. .....

Subject .....

Paper .....

Descriptive Type

Booklet No. B .....

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2 0 1 7

(5th Semester)

PHYSICS

FIFTH PAPER

(Mathematical Physics—I)

(Revised)

(PART : A—OBJECTIVE)

(*Marks* : 25)

The figures in the margin indicate full marks for the questions

SECTION—I

(*Marks* : 10)

Put a Tick ☑ mark against the correct answer in the boxes provided : 1×10=10

1. The value of $\left(\frac{3}{2}\right)$ is

(a) $\sqrt{\ }$ ☐

(b) $2\sqrt{\ }$ ☐

(c) $\frac{4}{3}\sqrt{\ }$ ☐

(d) $\frac{\sqrt{\ }}{3}$ ☐

2. The value of (3, 2) is

(a) $\frac{3}{2}$ □

(b) $\frac{2}{3}$ □

(c) $\frac{1}{10}$ □

(d) $\frac{1}{12}$ □

3. If $z \quad e^{i}$, then sin is given by

(a) $\frac{1}{2i} \; z \quad \frac{1}{z}$ □

(b) $\frac{1}{2} \; z \quad \frac{1}{z}$ □

(c) $\frac{1}{2i} \; z \quad \frac{1}{z}$ □

(d) $\frac{1}{2} \; z \quad \frac{1}{z}$ □

4. The function $f(z) \quad \frac{e^{z}}{z^{2} \quad a^{2}}$ has

(a) two simple poles at $z \quad ia$ and at $z \quad ia$ □

(b) two simple poles at $z \quad a$ and at $z \quad a$ □

(c) a simple pole at $z \quad a$ and a pole of order 2 at $z \quad a$ □

(d) a simple pole at $z \quad ia$ and a pole of order 2 at $z \quad ia$ □

5. Which of the following statements regarding a Hermitian matrix H is true?

(a) e^{iH} is also Hermitian matrix ☐

(b) H H , where H is the conjugate of H ☐

(c) The eigenvalues of the matrix H are imaginary ☐

(d) Any two eigenvectors corresponding to two distinct eigenvalues of H are orthogonal ☐

6. The eigenvalues of the matrix

$$A \quad \begin{matrix} 5 & 4 \\ 1 & 2 \end{matrix}$$

are

(a) 5, 4 ☐

(b) 6, 1 ☐

(c) 1, 2 ☐

(d) 4, 1 ☐

7. The scale factors for a spherical polar coordinate system are

(a) h_1 1, h_2 r, h_3 1 ☐

(b) h_1 1, h_2 , h_3 1 ☐

(c) h_1 1, h_2 r, h_3 $r \sin$ ☐

(d) h_1 1, h_2 r, h_3 sin ☐

8. If A^i and B_i are contravariant and covariant vectors respectively, then A^iB_i is

(a) invariant tensor ☐

(b) a covariant tensor of rank 2 ☐

(c) a contravariant tensor of rank 2 ☐

(d) a mixed tensor of rank 2 ☐

9. In C++, arithmetic operations $\frac{8}{5}$ and 8%5 respectively result in

(a) 1, 0 ☐

(b) 1, 3 ☐

(c) 3, 1 ☐

(d) 3, 0 ☐

10. What is the final value of *y* after executing the following three statements in C++?

int *x* 2, *y* 3;

x 5;

y *y* *x*;

(a) 5 ☐

(b) 7 ☐

(c) 8 ☐

(d) 10 ☐

SECTION—II

(*Marks* : 15)

Answer the following questions in brief : 3×5=15

1. Show that

$$\int_0 x^2 e^{-x^4}\,dx = \frac{1}{4}\Gamma\left(\frac{3}{4}\right)$$

2. Find the residue of $f(z)$ $\frac{2z^2}{4 \quad z^2}$ at all the singularities.

3. Show that any complex square matrix can be expressed as the sum of a Hermitian matrix and a skew-Hermitian matrix.

4. The expression of gradient in curvilinear coordinates is

$$\rightarrow \quad \frac{\hat{e}_1}{h_1}\frac{\quad}{u_1} \quad \frac{\hat{e}_2}{h_2}\frac{\quad}{u_2} \quad \frac{\hat{e}_3}{h_3}\frac{\quad}{u_3}$$

Hence write the expressions for gradient in Cartesian, cylindrical and spherical polar coordinates.

5. Write a C++ program to calculate the area and circumference of a circle. Take radius *r* as float-type data input and print the output of area (*A*) and circumference (*C*) of the circle.

★★★

2017

(5th Semester)

PHYSICS

SIXTH PAPER

(Quantum Mechanics—II)

(Pre-Revised)

Full Marks : 75

Time : 3 hours

(PART : B—DESCRIPTIVE)

(*Marks* : 50)

The figures in the margin indicate full marks for the questions

1. *(a)* What do you mean by duality of radiation and matter? Show that the de Broglie wavelength for a material particle of rest mass m_0 and charge q, accelerated from rest through a potential difference of V volt relativistically is given by

$$\frac{h}{\sqrt{2m_0qV\ 1\ \frac{qV}{2m_0c^2}}}$$

2+5=7

(b) What do you mean by quantum numbers? Write down the possible quantum numbers for n 2. 3

Or

(a) Write the main features of Bohr's theory of hydrogen atom. Derive the expressions for total energy of the electron. 2+3=5

(b) Show that material particle can only be represented by a group wave, not by a single wave. 5

2. *(a)* What do you mean by Hermitian operator? Show that two eigenfunctions of the same Hermitian operator belonging to two distinct eigenvalues are orthogonal. 1+4=5

(b) What is expectation value? Show that momentum operator is Hermitian. 1+4=5

Or

(a) Write down the addition and multiplication conditions to be satisfied by a vector space. 4

(b) Let | 2$|u_1$ 3$|u_2$ $i|u_3$ and | 3$|u_1$ 2$|u_2$ 4$|u_3$ and a constant a 3 3i. Compute the inner product | and $|a$. 3+3=6

3. *(a)* Obtain Schrödinger time independent equation. Give the physical interpretation. 6

(b) A wave function is given by Ae^{ikx}, show that the probability current density of the given wave function is given by $J \quad v|A|^2$ where v is velocity of the particle. 4

Or

(a) Obtain the equation for conservation of probability. Write the physical meaning of the equation. 7

(b) Write down the conditions to be satisfied by an acceptable wave function. 3

4. Obtain the expression for energy eigenvalue of one-dimensional harmonic oscillator. What do you mean by zero point energy? 8+2=10

Or

A free particle of energy E is incident on a potential step given by $V \quad 0$; $x \quad 0$ and $V \quad V_0$; $x \quad 0$. Show that all the waves are reflected when $E \quad V_0$. 10

5. *(a)* Write down Pauli spin matrices and show that $[\ ^2, \ _x] \quad 0$. 1+4=5

(b) What do you mean by orbital gyromagnetic ratio for an electron? Obtain the expression for it. 1+4=5

Or

(a) Show that the square of angular momentum commutes with any one of the components of angular momentum i.e., $[L^2, L_x] \quad 0$. What is the physical meaning of the commutation? 4+1=5

(b) Let $_x$, $_y$, $_z$ be Pauli spin matrices. Let $\vec{A}$ and $\vec{B}$ be two vectors. Show that

$(\vec{} \ \vec{A})(\vec{} \ \vec{B}) \quad \vec{A} \ \vec{B} \quad i\vec{} \ (\vec{A} \quad \vec{B})$ 5

★ ★ ★

Subject Code : PHY/V/06 (PR)

Booklet No. A

Date Stamp .....

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Paper .....

Descriptive Type

Booklet No. B .....

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Signature of Invigilator(s)

2 0 1 7

(5th Semester)

PHYSICS

SIXTH PAPER

(Quantum Mechanics—II)

(Pre-Revised)

(PART : A—OBJECTIVE)

(*Marks* : 25)

The figures in the margin indicate full marks for the questions

SECTION—I

(*Marks* : 10)

Put a Tick (✓) mark against the correct answer in the brackets provided : 1×10=10

1. The de Broglie wavelength of electron accelerated through potential difference of 144 V is about

(a) 12 angstrom ( )

(b) 1·2 angstrom ( )

(c) 0·10 angstrom ( )

(d) 10 angstrom ( )

2. Which of the following is not permissible set of quantum numbers for electrons in an atom?

(a) $n = 4, l = 0, m = 0, s = -1/2$ ( )

(b) $n = 5, l = 3, m = 0, s = +1/2$ ( )

(c) $n = 3, l = 2, m = -3, s = -1/2$ ( )

(d) $n = 3, l = 2, m = -2, s = -1/2$ ( )

3. The eigenvalues of Hermitian operators are

(a) real only ( )

(b) imaginary only ( )

(c) can be real or imaginary ( )

(d) always complex ( )

4. If the inner product between two vectors is zero, then the two vectors are

(a) orthogonal to each other ( )

(b) parallel to each other ( )

(c) Both *(a)* and *(b)* ( )

(d) Neither *(a)* nor *(b)* ( )

5. Let ψ be a wave function, the quantity $\int \psi^* \psi d\tau$ represents

(a) probability density ( )

(b) total probability ( )

(c) energy density ( )

(d) wave intensity ( )

6. Conservation of probability in quantum mechanics is represented by the equation

(a) $\frac{\partial \rho}{\partial t} + \vec{\nabla} \cdot \vec{J} = 0$ ( )

(b) $\frac{\partial \rho}{\partial t} - \vec{\nabla} \cdot \vec{J} = 0$ ( )

(c) $\frac{\partial \rho}{\partial t} + \vec{\nabla} \cdot \vec{P} = 0$ ( )

(d) $\frac{\partial \rho}{\partial t} - \vec{\nabla} \cdot \vec{P} = 0$ ( )

Where the symbols have their usual meaning.

7. For a free particle in one-dimensional infinite potential, the relation between energy eigenvalue (E_n) and the quantum state (n) is given by

(a) $E_n \propto n$ ( )

(b) $E_n \propto n^2$ ( )

(c) $E_n \propto \sqrt{n}$ ( )

(d) $E_n \propto \frac{1}{n^2}$ ( )

8. For a free particle in step potential, let R and T be reflectance and transmittance, then

(a) $R + T = 1$ ( )

(b) $R = T$ ( )

(c) $R - T = 1$ ( )

(d) $RT = 1$ ( )

9. For electron, the number of possible spin states for Z component is

(a) 1 ( )

(b) 2 ( )

(c) 3 ( )

(d) 4 ( )

10. Trace of Pauli spin matrices are

(a) 1 each ( )

(b) $-i$ each ( )

(c) -1 each ( )

(d) 0 each ( )

SECTION—II

(*Marks* : 15)

Give short answers to the following questions : 3×5=15

1. Show that group velocity v_g and phase velocity v_p are related to each other by

$$v_g = v_p - \lambda \frac{dv_p}{d\lambda}$$

2. Show that $[x, p_x^n] = ni\hbar p_x^{n-1}$, where x is position operator, p_x is x component of momentum operator.

3. Give the physical interpretation of wave function. What does normalization condition mean?

4. Normalised wave function of a free particle in a box is given by

$$\psi = \sqrt{\frac{2}{L}} \sin \frac{n\pi x}{L}$$

where $0 < x < L$. Obtain the probability of finding the particle within

$$0 < x < \frac{2}{L}$$

5. Show that electron spin magnetic moment is equal to Bohr Magneton.

★★★

2017

(5th Semester)

PHYSICS

SIXTH PAPER

(Quantum Mechanics—II)

(Revised)

Full Marks : 75

Time : 3 hours

(PART : B—DESCRIPTIVE)

(*Marks* : 50)

The figures in the margin indicate full marks for the questions

1. *(a)* What do you mean by 'wave packet'? Derive the expression for group velocity and show that it is equal to particle velocity. 1+4+1=6

(b) Find the relation between group velocity and phase velocity. Hence show that for a non-dispersive medium they are equal. 3+1=4

Or

(a) What do you mean by 'position probability density' denoted by $P(\vec{r}, t)$? Derive the equation of continuity for probability current density $\vec{J}$. 1+5=6

(b) Discuss two-slit experiment and explain complementary principle. 4

2. *(a)* A particle of energy E is incident on a step potential of height V_0. Show that for E V_0, there is a certain probability of being reflected as well as being transmitted and R T 1, where R is reflection coefficient and T is transmission coefficient. 6

(b) Discuss the application of quantum tunnelling in -decay. 4

Or

(a) Show that, $[\hat{p}, \hat{x}]$ $i\hbar$ where $\hat{x}$ and $\hat{p}$ are position and momentum operators respectively. What is the physical significance of this relation? 3+1=4

(b) Show that the eigenvalues of Hermitian operator are real. 4

(c) If $\hat{A}$ and $\hat{B}$ are Hermitian operators, show that $[\hat{A}, \hat{B}]$ is skew-Hermitian operator. 2

3. *(a)* A free particle of mass m moves in a three-dimensional rectangular potential box of sides a, b and c parallel to x-, y- and z-axes respectively. Derive the expression for its normalized wave function and show that the energy eigenvalue for its ground state is given by

$$E_{1,1,1} \quad \frac{^2\hbar^2}{2m}\ \frac{1}{a^2}\ \frac{1}{b^2}\ \frac{1}{c^2} \qquad 7$$

(b) If the potential box is cubical each of side a, then show that the first excited state is three-fold degenerate. Find the energy eigenvalue for this state. 2+1=3

Or

(a) The ground-state eigenfunction of a simple harmonic oscillator is given by

$$_0(x) \quad Ae^{\ a^2x^2/2}$$

where A is a constant and $a^2 \quad m \quad /\hbar$. Find the value of A and write the normalized wave function. Given

$$_0 e^{\ a^2x^2}dx \quad \frac{\sqrt{\ }}{2a} \qquad 2$$

(b) Assuming potential energy of the oscillator as $V(x) \quad \frac{1}{2}m \quad ^2x^2$, calculate the average value of kinetic energy and potential energy. Given

$$_0 x^2e^{\ a^2x^2}dx \quad \frac{\sqrt{\ }}{4a^3} \qquad 3$$

(c) Write the time-independent Schrödinger equation in the operator form for the simple harmonic oscillator. Hence show that the energy eigenvalue in the ground state is $E_0 \quad \frac{1}{2}\hbar$. 5

4. *(a)* What do you mean by 'a set of n-vectors, $\vec{a}_1, \vec{a}_2, ..., \vec{a}_r$ is linearly independent'? 2

(b) Check whether the following sets of vectors form the basis set in R^3 vector space : 4

(2, 0, 2), (0, 2, 0), (2, 0, 2)

(c) Use the Gram-Schmidt process to transform the basis vectors u_1 (1, 1, 1), u_2 (1, 1, 0) and u_3 (1, 2, 1) into an orthogonal basis (v_1, v_2, v_3). 4

Or

(a) What are the conditions to be satisfied by a set of n vectors to form the basis set in an n-dimensional vector space? 2

(b) Consider the following four elements from the vector space of real 2 2 matrices :

$$|1\rangle \quad \begin{matrix} 1 & 0 \\ 0 & 0 \end{matrix} \qquad |2\rangle \quad \begin{matrix} 0 & 1 \\ 0 & 0 \end{matrix} \qquad |3\rangle \quad \begin{matrix} 0 & 0 \\ 1 & 0 \end{matrix} \qquad |4\rangle \quad \begin{matrix} 0 & 0 \\ 0 & 1 \end{matrix}$$

Show whether they form a basis set or not. 4

(c) Write down the condition for orthonormality of state vectors $|\ _m\rangle$ and $|\ _n\rangle$. If

$|\ _m\rangle$ $2|u_1\rangle$ $3|u_2\rangle$ $i|u_3\rangle$ and

$|\ _n\rangle$ $3|u_1\rangle$ $i|u_2\rangle$ $4|u_3\rangle$

find $\langle\ _m|\ _n\rangle$ and $\langle\ _n|\ _m\rangle$. 2+1+1=4

5. *(a)* Starting from the Cartesian components of linear momentum operators, find the Cartesian components of angular momentum operator. 3

(b) Show that

(i) $[L_y, L_z]$ $i\hbar L_x$

(ii) $[L_x, p_x]$ 0

where the symbols have their usual meanings. 3+2=5

(c) Suppose we measure the magnitude of angular momentum of a system and find the value, L^2 $6\hbar^2$. How many orientations of $\vec{L}$ are there with respect to *z*-axis? What are the corresponding values of L_z? 2

Or

(a) How are the Cartesian components of spin operators ($\hat{S}_x$, $\hat{S}_y$, $\hat{S}_z$) related to their respective Pauli spin operators ($\hat{}_x$, $\hat{}_y$, $\hat{}_z$)? Write their corresponding eigenvalues. 2

(b) Show that

(i) $[\ _x,\ _y]$ $2i\ _z$

(ii) $_z\ _x$ $\quad$ $_x\ _z$ 0 2+2=4

(c) Taking the value of Pauli spin matrix as

$$_z \quad \begin{matrix} 1 & 0 \\ 0 & 1 \end{matrix}$$

find the values of matrices $_x$ and $_y$. 4

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Subject Code : PHY/V/06 (R)

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2 0 1 7

(5th Semester)

PHYSICS

SIXTH PAPER

(Quantum Mechanics—II)

(Revised)

(PART : A—OBJECTIVE)

(*Marks* : 25)

The figures in the margin indicate full marks for the questions

SECTION—I

(*Marks* : 10)

Put a Tick (✓) mark against the correct answer in the brackets provided : 1×10=10

1. The value of the de Broglie wavelength of an electron having kinetic energy of 9 eV is

(a) 4·09 Å ( )

(b) 1·36 Å ( )

(c) 0·4 Å ( )

(d) 13·6 Å ( )

2. Which of the following conditions cannot be satisfied by a well-behaved wave function ψ ?

(a) ψ must be finite for all values of x, y and z ( )

(b) ψ must be single-valued at each point (x, y, z) ( )

(c) ψ must be continuous for all regions ( )

(d) ψ must be a real function of x, y, z, t ( )

3. The quantum mechanical tunnelling provides an explanation for the following physical phenomena except

(a) the emission of alpha particles from a radioactive nucleus ( )

(b) the motion of electrons inside an atom ( )

(c) the electrical breakdown of insulators ( )

(d) the switching action of a tunnel diode ( )

4. If the operator $\hat{A} \equiv \frac{d^2}{dx^2}$ operates on the eigenfunction $\psi(x) = \sin 2x$, the eigenvalue is

(a) 1 ( )

(b) 2 ( )

(c) 4 ( )

(d) -4 ( )

5. The total number of energy levels (or degeneracy) for the *n*th state of hydrogen atom is

(a) n ( )

(b) $n+1$ ( )

(c) n^2 ( )

(d) n^2+1 ( )

6. The momentum eigenvalue for a particle trapped in cubical box of side a in the ground state$(1, 1, 1)$ is

(a) $\frac{3\pi\hbar}{a}$ ( )

(b) $\frac{\sqrt{3}\pi\hbar}{a}$ ( )

(c) $\frac{6\pi\hbar}{a}$ ( )

(d) $\frac{\sqrt{6}\pi\hbar}{a}$ ( )

7. If $|\psi\rangle$ and $|\phi\rangle$ are vectors in linear vector spaces and a, b are arbitrary complex numbers, then $\langle a\psi | b\phi\rangle$ is equal to

(a) $ab\langle\psi|\phi\rangle$ ( )

(b) $a^* b\langle\psi|\phi\rangle$ ( )

(c) $a^* b^*\langle\psi|\phi\rangle$ ( )

(d) $ab^*\langle\psi|\phi\rangle$ ( )

8. If $|\psi_m\rangle$ and $|\psi_n\rangle$ be two eigenvectors having eigenvalues λ_m and λ_n corresponding to the operator $\hat{\alpha}$, then

(a) $\langle\psi_m|\psi_n\rangle = 0$ ( )

(b) $\langle\psi_m|\psi_n\rangle = 1$ ( )

(c) $\langle\psi_m|\psi_n\rangle = -1$ ( )

(d) $\langle\psi_m|\psi_n\rangle \geq 0$ ( )

9. The Bohr magneton is defined as the magnetic dipole moment associated with an atom due to

(a) orbital motion of an electron in the first stationary orbit ( )

(b) orbital motion of an electron in the first excited state ( )

(c) orbital motion of an electron in presence of magnetic field ( )

(d) electron spin ( )

10. The eigenvectors of $\sigma_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$ are

(a) $\begin{pmatrix} 1 \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ 1 \end{pmatrix}$ ( )

(b) $\begin{pmatrix} 1 \\ i \end{pmatrix}, \begin{pmatrix} 1 \\ -i \end{pmatrix}$ ( )

(c) $\begin{pmatrix} 1 \\ 1 \end{pmatrix}, \begin{pmatrix} 1 \\ -1 \end{pmatrix}$ ( )

(d) $\begin{pmatrix} 1 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 \\ 1 \end{pmatrix}$ ( )

SECTION—II

(*Marks* : 15)

Give short answers to the following questions : 3×5=15

1. Find the normalization constant A for the wave function $y(x) = A \sin \frac{npx}{a}$ and hence find the expectation values of x for the particle moving between 0 and a.

2. Show that the momentum operator $\hat{p}_x = -i\hbar \frac{d}{dx}$ is a Hermitian operator.

3. What is the significance of zero-point energy (E_0) in linear harmonic oscillator? Express energy eigenvalues (E_n) in terms of E_0.

4. Show that the three vectors $a = (1, 2, 3)$, $b = (3, -1, 1)$ and $c = (1, 1, -2)$ in R^3-space are linearly independent.

5. Explain the concept of electron spin as introduced by Uhlenbeck and Goudsmit.

★★★

2017

(5th Semester)

PHYSICS

SEVENTH PAPER

(Classical Mechanics and Thermal Physics)

(Pre-revised)

Full Marks : 55

Time : 2½ hours

(PART : B—DESCRIPTIVE)

(*Marks* : 35)

The figures in the margin indicate full marks for the questions

1. *(a)* Show that a two-body problem can be reduced to a one-body problem. 3

(b) Deduce Kepler's law of planetary motion from Newton's law. 4

Or

(c) Explain the principle of virtual work. 3

(d) Using Hamiltonian formulation, obtain the equation of motion for a simple pendulum. 4

2. Describe how Perrin verified Einstein theory of Brownian motion experimentally and led him to determine Avogadro's number. 7

Or

Deduce the Maxwell-Boltzmann law for the distribution of velocities. 7

3. *(a)* Derive an expression for the coefficient of thermal conductivity. 4

(b) Define Helmholtz function F. Show that the change in Helmholtz function during an infinitesimal reversible process is $dF \quad PdV \quad SdT$. 1+2=3

Or

(c) What is triple point? 1

(d) Deduce the four Maxwell's thermodynamical relations from thermodynamical energy function. 6

4. *(a)* Define accessible states. 1

(b) Calculate the number of phase cells in energy range of 0 to E, for a linear simple harmonic oscillator and a free particle of mass m and frequency . 6

Or

(c) State the theorem of equipartition of energy. 1

(d) Derive Boltzmann's canonical distribution law. 6

5. *(a)* Discuss indistinguishability of a particle in Bose-Einstein and Fermi-Dirac statistics. 2

(b) Using Maxwell-Boltzmann distribution law, show that the internal energy of an ideal monatomic gas depends only on its temperature. Hence show that C_v $\frac{3}{2}R$. 4+1=5

Or

(c) Write any two point of differences between Bose-Einstein and Fermi-Dirac statistics. 2

(d) Starting from Fermi-Dirac distribution law, derive the expression for energy distribution of free electrons in a metal. 5

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2 0 1 7

(5th Semester)

PHYSICS

SEVENTH PAPER

(Classical Mechanics and Thermal Physics)

(Pre-revised)

(PART : A—OBJECTIVE)

(*Marks* : 20)

The figures in the margin indicate full marks for the questions

SECTION—I

(*Marks* : 5)

Tick (✓) the correct answer in the brackets provided : 1×5=5

1. Lagrange's equation for generalized coordinate is given by

(a) $\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial q}\right) - \frac{\partial L}{\partial \dot{q}} = 0$ ( )

(b) $\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial q}\right) + \frac{\partial L}{\partial \dot{q}} = 0$ ( )

(c) $\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \dot{q}}\right) - \frac{\partial L}{\partial q} = 0$ ( )

(d) $\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \dot{q}}\right) + \frac{\partial L}{\partial q} = 0$ ( )

2. The most probable velocity of a gas molecule is

(a) $\sqrt{\frac{m}{3kT}}$ ( )

(b) $\sqrt{\frac{3kT}{m}}$ ( )

(c) $\sqrt{\frac{m}{2kT}}$ ( )

(d) $\sqrt{\frac{2kT}{m}}$ ( )

3. Viscosity of a gas is due to the transport of

(a) energy ( )

(b) mass ( )

(c) momentum ( )

(d) velocity ( )

4. The thermodynamic probability of a system in equilibrium is

(a) maximum ( )

(b) minimum but not 1 ( )

(c) 1 ( )

(d) 0 ( )

5. Deduction of Planck's law is possible on the basis of

(a) Fermi-Dirac statistics ( )

(b) Classical statistics ( )

(c) Maxwell-Boltzmann statistics ( )

(d) Bose-Einstein statistics ( )

SECTION—II

(*Marks* : 15)

Answer the following questions : 3×5=15

1. Obtain the gravitational potential for a thin spherical shell.

2. Obtain the equation for the mean or average speed of a gas molecule.

3. Show that for a perfect gas $C_p - C_v = R$.

4. What are canonical, micro-canonical and grand-canonical ensembles?

5. How does Fermi energy vary with temperature?

★★★

2017

(5th Semester)

PHYSICS

SEVENTH PAPER

(Classical Mechanics and Thermal Physics)

(Revised)

Full Marks : 55

Time : 2½ hours

(PART : B—DESCRIPTIVE)

(*Marks* : 35)

The figures in the margin indicate full marks for the questions

1. *(a)* By reducing a two-body problem to a one-body problem, find the equation of motion of the equivalent one-body. 3

(b) Deduce Kepler's third law of planetary motion from Newton's law of gravitation. 4

Or

(a) Explain the terms 'constraints' and 'generalized coordinates'. 2

(b) Using Hamiltonian formulation, obtain the equation of motion for a simple pendulum. 5

2. What is Brownian motion? Discuss Einstein's theory of Brownian motion. 1+6=7

Or

Deduce the Maxwell-Boltzmann law for the distribution of velocities of the particles of a gas. 7

3. *(a)* Define 'viscosity' and 'coefficient of viscosity'. 2

(b) Show that the coefficient of viscosity of a gas is $\frac{1}{3} pc$, where the symbols have their usual meanings. 5

Or

Deduce Gibbs' phase rule. Using the phase rule, show that a quantity of water in equilibrium with its vapour in a cylinder fitted with a piston is a univariant system. 7

4. *(a)* Derive the relation $S \quad k \ln (E)$, where S entropy and (E) thermodynamic probability. 4

(b) Show that for thermodynamics equilibrium of any two systems in contact, the parameter of the two systems must be equal. 3

Or

Define ensemble. Explain microcanonical, canonical and grand canonical ensembles with necessary diagrams. 1+6=7

5. *(a)* Find the specific heat at constant volume of an ideal gas using M-B energy distribution law. 3

(b) Using F-D statistics, determine the Fermi energy of an electron gas in metal. 4

Or

Find the expression for the most probable distribution of the particles among various energy levels for a system obeying B-E statistics. 7

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Subject Code : PHY/V/07 (R)

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PHY/V/07 (R)

2 0 1 7

(5th Semester)

PHYSICS

SEVENTH PAPER

(Classical Mechanics and Thermal Physics)

(Revised)

(PART : A—OBJECTIVE)

(*Marks* : 20)

The figures in the margin indicate full marks for the questions

SECTION—I

(*Marks* : 5)

Put a Tick (✓) mark against the correct answer in the brackets provided : 1×5=5

1. If there are no external forces acting on a system of particles, then

(a) the total momentum of the system is constant ( )

(b) the velocity of centre of mass is constant ( )

(c) Both *(a)* and *(b)* ( )

(d) Neither *(a)* nor *(b)* ( )

2. If $c_{r.m.s.}$ = root-mean-square speed, c = average speed and c_p = most probable speed of the molecules of an ideal gas, then

(a) $c_{r.m.s.} = c = c_p$ ( )

(b) $c_{r.m.s.} > c > c_p$ ( )

(c) $c_{r.m.s.} < c < c_p$ ( )

(d) $c_{r.m.s.} > c = c_p$ ( )

3. The total heat content of a system is called

(a) internal energy ( )

(b) Helmholtz free energy ( )

(c) enthalpy ( )

(d) Gibbs' free energy ( )

4. In which of the following ensembles, a system can exchange energy as well as particle?

(a) Microcanonical ensemble ( )

(b) Canonical ensemble ( )

(c) Grand canonical ensemble ( )

(d) Both *(b)* and *(c)* ( )

5. Particles obeying Pauli's exclusion principle obey

(a) M-B statistics ( )

(b) F-D statistics ( )

(c) B-E statistics ( )

(d) Both *(a)* and *(b)* ( )

SECTION—II

(*Marks* : 15)

Answer the following questions : 3×5=15

1. Define central force and non-central force. Give an example of each.

2. At what temperature the r.m.s. velocity of oxygen will become one-half of that of hydrogen at NTP?

3. What is the importance of *TdS*-equation? Derive the second *TdS*-equation

$$TdS = C_p dT - T(\partial V / \partial T)_p dP$$

4. State and explain the principle of equi-apriori probability.

5. Define Fermi level and Fermi energy. How is Fermi energy related to Fermi temperature?

★★★

2017

(5th Semester)

PHYSICS

EIGHTH (A) PAPER

(Spectroscopy)

(Pre-revised)

Full Marks : 55

Time : 2½ hours

(PART : B—DESCRIPTIVE)

(*Marks* : 35)

The figures in the margin indicate full marks for the questions

1. *(a)* State and explain the basic postulates of Bohr's atomic model. Derive the expression for total energy of an electron. 2+5=7

Or

(b) Discuss the Sommerfeld's elliptical model of an atom and obtain the fine structure of H-line. 5+2=7

2. *(a)* State and explain Pauli's exclusion principle. On the basis of this principle, how do you calculate the number of electrons that can occupy a sub-shell inside an atom? 1+2+4=7

Or

(b) What are normal and anomalous Zeeman effect? Give the classical interpretation of normal Zeeman effect and derive the expression for Zeeman shift. 2+3+2=7

3. *(a)* What is population inversion in LASER system? Explain the mechanism of getting population inversion in three-level system. 2+5=7

Or

(b) With necessary diagram, explain the construction and working of any *one* of the following : 7

(i) He-Ne LASER

(ii) Semiconductor LASER

4. *(a)* With necessary diagram, obtain an expression for the energy level, frequency of spectral line and the selection rule in non-rigid rotator. 3+3+1=7

Or

(b) What is the intermolecular distance of an atom? Calculate the intermolecular distance of CO molecule.

Given,

Atomic weight of Oxygen = 15·99 amu, and Carbon = 12·01 amu,

h $6{\cdot}62 \times 10^{-27}$ erg.sec,

c 3×10^{10} cm sec^{-1} 1+6=7

5. *(a)* What is Raman effect? Discuss the quantum mechanical explanation of Raman effect. 2+5=7

Or

(b) Define the *P*, *Q* and *R* branches in the spectrum of rotational fine structure in electronic vibrational transition. 4

(c) Define the Frank-Condon principle. What information is observed in this principle? 2+1=3

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Subject Code : **PHY/V/08 (a) (PR)**

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2 0 1 7

(5th Semester)

PHYSICS

EIGHTH (A) PAPER

(Spectroscopy)

(Pre-revised)

(PART : A—OBJECTIVE)

(*Marks* : 20)

The figures in the margin indicate full marks for the questions

SECTION—A

(*Marks* : 5)

Tick (✓) the correct answer in the brackets provided : 1×5=5

1. The radius of Bohr's second orbit for hydrogen atom is

(a) 0·053 nm ( )

(b) 0·106 nm ( )

(c) 0·212 nm ( )

(d) 0·318 nm ( )

2. Stark effect is splitting of atomic spectral lines due to the application of

(a) external photon energy ( )

(b) internal photon energy ( )

(c) external electric field ( )

(d) external magnetic field ( )

3. Which of the following is correct about Einstein's A and B coefficients in a LASER system?

(a) Coefficient A is related to spontaneous emission and coefficient B is related to absorption and stimulated emission ( )

(b) Coefficient A is related to spontaneous emission and absorption and coefficient B is related to stimulated emission ( )

(c) Coefficient A is related to spontaneous and stimulated emission and coefficient B is related to absorption and emission ( )

(d) Coefficient A is related to absorption and stimulated emission and coefficient B is related to spontaneous emission ( )

4. The zero point energy of a vibrating diatomic molecule is (here ω_{os} is oscillating frequency)

(a) $\frac{1}{4} h\omega_{os}$ joule ( )

(b) $\frac{1}{2} h\omega_{os}$ joule ( )

(c) $h\omega_{os}$ joule ( )

(d) $2h\omega_{os}$ joule ( )

5. If one electron is removed from O_2 molecule, it will be in one of the highest energy ($\pi_g^* 2p$) orbitals, this electron is called

(a) anti-bonding electron ( )

(b) bonding electron ( )

(c) π-bonding electron ( )

(d) σ-bonding electron ( )

SECTION—B

(*Marks* : 15)

Answer the following questions : 3×5=15

1. Define Larmor's theorem.

2. What is Auger effect? Explain the emission of Auger electron.

3. What are the properties of LASER?

4. Explain the basic idea of Born-Oppenheimer approximation.

5. What is Fortrat diagram? What information are given by this diagram?

★★★

2017

(5th Semester)

PHYSICS

EIGHTH (A) PAPER

(Spectroscopy)

(Revised)

Full Marks : 55

Time : 2½ hours

(PART : B—DESCRIPTIVE)

(*Marks* : 35)

The figures in the margin indicate full marks for the questions

1. Derive the formula for Rutherford's scattering cross-section. Discuss Rutherford's atomic model and its failure. 4+3=7

Or

Give the postulates of Bohr's theory and derive an expression for the Rydberg constant. Explain why the value of this constant for helium is different than that for hydrogen. 2+4+1=7

2. Discuss Stern-Gerlach experiment. Discuss its importance. What did the experiment establish? 4+2+1=7

Or

What is the physical interpretation of various quantum numbers? What is meant by *L-S* coupling? Deduce the spectral terms which can arise from two non-equivalent *p*-electrons. 3+1+3=7

3. What is Zeeman effect? Derive an expression for normal Zeeman splitting and illustrate with a diagram. Give a point of difference between normal and anomalous Zeeman effect. 2+4+1=7

Or

(a) Considering a three-level laser system, write the laser rate equations. 3

(b) Solve the rate equations under steady-state conditions and derive an expression for the population difference between the first and second energy levels. What is the condition for achieving population inversion? 3+1=4

4. Obtain the expression for the rotational energy of non-rigid diatomic molecule. Write the applicable selection rules. Compare the energy level diagram with that of rigid rotator. 3+1+3=7

Or

Obtain the expression for the allowed energies for a vibrating molecule treated as a harmonic oscillator. Draw the energy level diagram. Show that the vibrational spectrum consists of a single band. 3+2+2=7

5. *(a)* State and explain Frank-Condon principle. 3

(b) Define the energy level in rotational fine structure of vibrational transition and also explain the significance of *P*, *Q*, *R* branches. 4

Or

(c) What is Raman effect? Give its explanation. What is the difference between Raman spectra with Infrared spectra? 2+3+2=7

★ ★ ★

Subject Code : PHY/V/08 (a) (R)

Booklet No. A

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DEGREE 5th Semester
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2 0 1 7

(5th Semester)

PHYSICS

EIGHTH (A) PAPER

(Spectroscopy)

(Revised)

(PART : A—OBJECTIVE)

(*Marks* : 20)

The figures in the margin indicate full marks for the questions

SECTION—A

(*Marks* : 5)

Tick (✓) the correct answer in the brackets provided : 1×5=5

1. In the hydrogen spectrum, the wavelength corresponding to the Balmer series of lines is given by

(a) $\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right),\ n = 3,\ 4,\ \ldots$ ( )

(b) $\frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{n^2}\right),\ n = 4,\ 5,\ \ldots$ ( )

(c) $\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right),\ n = 2,\ 3,\ \ldots$ ( )

(d) $\frac{1}{\lambda} = R\left(\frac{1}{4^2} - \frac{1}{n^2}\right),\ n = 5,\ 6,\ \ldots$ ( )

2. The angle between $\vec{L}$ and $\vec{S}$ vectors, in the vector atom model, is given by

(a) $\cos(\vec{S}, \vec{L}) = \dfrac{J(J+1) + S(S+1) - L(L+1)}{2\sqrt{L(L+1)}\sqrt{S(S+1)}}$ ( )

(b) $\cos(\vec{S}, \vec{L}) = \dfrac{L(L+1) + S(S+1) - J(J+1)}{2\sqrt{L(L+1)}\sqrt{S(S+1)}}$ ( )

(c) $\cos(\vec{S}, \vec{L}) = \dfrac{L(L+1) + J(J+1) - S(S+1)}{2\sqrt{L(L+1)}\sqrt{S(S+1)}}$ ( )

(d) $\cos(\vec{S}, \vec{L}) = \dfrac{L(L+1) + S(S+1) - J(J+1)}{2L(L+1)S(S+1)}$ ( )

3. The X-ray fine structure in X-ray spectra arises due to energy levels

(a) corresponding to different sub-shells of an electronic shell ( )

(b) splitted when the target material is placed in magnetic field ( )

(c) corresponding to spatial quantization of quantum numbers ( )

(d) Both *(b)* and *(c)* ( )

4. The zero-point energy of a vibrating-diatomic molecule (having ω_{os} hertz as oscillating frequency) is

(a) $\frac{1}{2} h\omega_{os}$ joule ( )

(b) $\frac{1}{4} h\omega_{os}$ joule ( )

(c) $h\omega_{os}$ joule ( )

(d) $\frac{3}{4} h\omega_{os}$ joule ( )

5. Fine structure in molecular spectra are produced by changes in the

(a) rotational levels ( )

(b) vibrational levels ( )

(c) electronic levels ( )

(d) energy levels ( )

SECTION—B

(*Marks* : 15)

Answer the following questions : 3×5=15

1. The series limit wavelength of the Balmer series in hydrogen spectrum is 3636 Å. Calculate Rydberg constant in cm^{-1}.

2. What is spatial quantization? What are the possible number of orientations for $l = 1$ and $l = 2$?

3. Write a brief note on X-ray fluorescence.

4. Calculate the intermolecular distance for CO molecules.

(Given $B = 1 \cdot 921 \text{ cm}^{-1}$, $h = 6 \cdot 627 \times 10^{-27}$ erg s

$c = 3 \times 10^{10}$ cm / s, $m_1 = 12$ g, $m_2 = 15 \cdot 9949$ g)

5. A substance shows a Raman line at 4567 Å when excited by 4358 Å. Deduce the positions of Stokes and anti-Stokes lines for the same substance when excited by 4047 Å radiation.

★★★

2 0 1 7

(5th Semester)

PHYSICS

EIGHTH (B) PAPER

(C Language and Numerical Methods)

(Pre-Revised)

Full Marks : 55

Time : 2½ hours

(PART : B—DESCRIPTIVE)

(*Marks* : 35)

The figures in the margin indicate full marks for the questions

1. *(a)* What do you mean by keywords and identifiers in C language? How do they differ from each other? Give examples. Also mention the characters that are not allowed within identifiers. 4

(b) Write the equivalent C expression for the following algebraic expressions : 3

(i) $\frac{2AB+2BC+2CA}{2A}$

(ii) $\frac{4}{3}x^2$

(iii) $\frac{b^2-4ac}{2a}$

Or

(c) What are the three basic data types in C? How are they used in variable declaration? Give examples. 3

(d) What are arithmetic, relational and logical operators? Explain with examples. What will be the output value of the following C program segment? 4

```
{
    int a=4;
    int b=1, sum;
    a++;
    b+=5;
    sum=b*3/4+a;
  printf("value of sum is %d\n", sum);
}
```

2. *(a)* What are the formatted and unformatted input and output operators in C? Explain how these commands are used in C programming with examples. 5

(b) Using a formatted input and output commands, write a simple C program to enter one integer and one real number and then print the integer and the real number entered. 2

Or

(c) What are standard library functions and user-defined functions? How are these functions declared in C program? 4

(d) Write a C programming code for defining a function to interchange two integers. 3

3. *(a)* What do you mean by array of pointers? Explain using example. 3

(b) Explain how to perform passing pointers to functions in C with example. 4

Or

(c) Explain how structure can be defined and accessed in C programming. 2+2=4

(d) What is an array within structure? Illustrate with example. 3

4. *(a)* Explain bisection method and Newton-Raphson method of solving equations. Draw appropriate graphical diagrams for illustration of the two methods. 4

(b) Calculate the first iteration in solving $2x^3 - 2 \cdot 5x - 5 = 0$ by Newton-Raphson method. 3

Or

Explain Gregory-Newton forward difference interpolation. Given the following data, estimate $f(1 \cdot 83)$ using Newton-Gregory forward difference interpolation polynomial : 4+3=7

i	0	1	2	3	4
x_i	1·0	3·0	5·0	7·0	9·0
f_i	0	1·0986	1·6094	1·9459	2·1972

5. Explain Simpson's rule of numerical integration. Compute the integral $\int_0^1 e^{x^2} dx$ using both Simpson's rules. The values of $y = e^{x^2}$ is given below : 3+4=7

x	0·0	0·1	0·2	0·3	0·4	0·5
y	1·00000	1·01005	1·04081	1·09417	1·17351	1·28402

x	0·6	0·7	0·8	0·9	1·0
y	1·43332	1·63231	1·89648	2·2479	2·71828

Or

Write the logic expressions, logic diagrams and truth tables of the first and second De Morgan's theorems. Using De Morgan's theorem, show that

$$\overline{\overline{A + B\overline{C}} + D(\overline{E + \overline{F}})} = (A + B\overline{C})(\overline{D} + E + \overline{F})$$

4+3=7

★★★

Subject Code : PHY/V/08(b) (PR)

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2 0 1 7

(5th Semester)

PHYSICS

EIGHTH (B) PAPER

(C Language and Numerical Methods)

(Pre-Revised)

(PART : A—OBJECTIVE)

(*Marks* : 20)

The figures in the margin indicate full marks for the questions

SECTION—I

(*Marks* : 5)

Put a Tick (✓) mark against the correct answer in the brackets provided : 1×5=5

1. In C programming, the storage size of character data type is

(a) 1 byte ( )

(b) 4 bytes ( )

(c) 8 bytes ( )

(d) 10 bytes ( )

2. A standard function, which can read from standard input only, is

(a) getch() ( )

(b) getc() ( )

(c) getche() ( )

(d) getchar() ( )

3. In C program, a special data type that allows to store different data types in the same memory location is

(a) array ( )

(b) pointer ( )

(c) union ( )

(d) structure ( )

4. The number of significant figure in 1.00 is

(a) 1 ( )

(b) 2 ( )

(c) 3 ( )

(d) 4 ( )

5. Octal number 25_8 equivalent in binary system is

(a) 10101_2 ( )

(b) 10111_2 ( )

(c) 10011_2 ( )

(d) 10110_2 ( )

SECTION—II

(*Marks* : 15)

Give short answers of the following questions : 3×5=15

1. What are the functions of semicolons and comments in C language? Explain with examples.

2. What are arrays? Explain declaration and initialization of arrays in C with examples.

3. What are pointers? Give at least two examples of valid pointer declaration in C.

4. What are absolute and relative errors?

5. What are binary and hexadecimal number systems?

★★★

2 0 1 7

(5th Semester)

PHYSICS

EIGHTH (B) PAPER

(C Language and Numerical Methods)

(Revised)

Full Marks : 55

Time : 2½ hours

(PART : B—DESCRIPTIVE)

(*Marks* : 35)

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1. *(a)* What do you mean by keywords and identifiers in C language? How do they differ from each other? Give examples. Also mention the characters that are not allowed within identifiers. 4

(b) Write the equivalent C expressions for the following algebraic expressions : 3

(i) $\frac{2AB+2BC+2CA}{2A}$

(ii) $\frac{4}{3}x^2$

(iii) $\frac{b^2-4ac}{2a}$

Or

(a) What are the three basic data types in C? How are they used in variable declaration? Give examples. 3

(b) What are arithmetic, relational and logical operators? Explain with examples. What will be the output value of the following C program segment? 4

```
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    b+=5;
    sum=b*3/4+a;
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}
```

2. *(a)* What are the formatted and unformatted input and output operators in C? Explain how these commands are used in C programming with examples. 5

(b) Using formatted input and output commands, write a simple C program to enter one integer and one real number, and then print the integer and real number entered. 2

Or

(a) What are standard library functions and user-defined functions? How are these functions declared in C program? 4

(b) Write a C programming code for defining a function to interchange two integers. 3

3. Explain the workings of IF, If-Else and nested If-Else statements using flow diagrams. Write a C program using If-Else statement to compare two integers and print the larger integer. 4+3=7

Or

(a) What are arrays? Explain declaration and initialization of arrays in C with examples. 3

(b) Write a C program to calculate the sum of the first 5 integers using While loop statement. 4

4. *(a)* Explain bisection method and Newton-Raphson method of solving equations. Draw appropriate graphical diagrams for illustration of the two methods. 4

(b) Calculate the first iteration in solving $2x^3 - 2 \cdot 5x - 5 = 0$ by Newton-Raphson method. 3

Or

Explain Gregory-Newton forward difference interpolation. Given the following data, estimate $f(1 \cdot 83)$ using Newton-Gregory forward difference interpolation polynomial : 4+3=7

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x	0·0	0·1	0·2	0·3	0·4	0·5
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4+3=7

★★★

Subject Code : PHY/V/08(b) (R)

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2 0 1 7

(5th Semester)

PHYSICS

EIGHTH (B) PAPER

(C Language and Numerical Methods)

(Revised)

(PART : A—OBJECTIVE)

(*Marks* : 20)

The figures in the margin indicate full marks for the questions

SECTION—I

(*Marks* : 5)

Put a Tick (✓) mark against the correct answer in the brackets provided : 1×5=5

1. In C programming, the storage size of character data type is

(a) 1 byte ( )

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(d) 10 bytes ( )

2. A standard function, which can read from standard input only, is

(a) getch() ( )

(b) getc() ( )

(c) getche() ( )

(d) getchar() ( )

3. The output of the following C program

```
{
    int sum;
    for (int a=1; a<3; a=a+1)
    {
    sum=a+2;
    }
    printf(a);
}
```

will be

(a) 2 ( )

(b) 4 ( )

(c) 6 ( )

(d) 8 ( )

4. The number of significant figures in 1.00 is

(a) 1 ( )

(b) 2 ( )

(c) 3 ( )

(d) 4 ( )

5. Octal number 25_8 equivalent in binary system is

(a) 10101_2 ( )

(b) 10111_2 ( )

(c) 10011_2 ( )

(d) 10110_2 ( )

SECTION—II

(*Marks* : 15)

Give short answers of the following questions : 3×5=15

1. What are the functions of semicolons and comments in C language? Explain with examples.

2. Write a C program to execute summation of two integers using function.

3. What are pointers? Give at least two examples of valid pointer declaration in C.

4. What are absolute and relative errors?

5. What are binary and hexadecimal number systems?

★★★