No. of Printed Pages : 05 Roll No. .....

24031

M. Sc. EXAMINATION, Dec. 2018

(First Semester)

PHYSICS

18PHY21HC1

MATHEMATICAL PHYSICS

Time : 3 Hours] [*Maximum Marks : 80*

Note : Q. No. **1** is compulsory. Attempt *one* question from each Unit.

1. (a) Show that components of a vector $\vec{A}$ along and perpendicular to the vector $\vec{B}$ may be expressed as $\frac{(\vec{A}\cdot\vec{B})\vec{B}}{B^2}$ and $\frac{\vec{B}\times(\vec{A}\times\vec{B})}{B^2}$, respectively. **4**

(b) Write about Wromkian's second order differential equation and what is its physical significance ? 4

(c) Define Dirac-delta function. State its two properties. 4

(d) Differentiate between poles and essential singularities of an analytical function. 4

Unit I

2. (a) Apply Gram-Schmidt orthogonalization to the following vector in $1R^3$: 8

$$\begin{bmatrix} 1 \\ 2 \\ 0 \end{bmatrix}, \begin{bmatrix} 8 \\ 1 \\ -6 \end{bmatrix}, \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

(b) Define vector space, linear independence, basis and dimension, orthogonal basis of vectors, eigen values and eigen vectors. 8

3. (a) Define Hermitian and orthogonal matrix. Give one example of each. Find the matrics C and C^{-1} required to reduce the matrix $A = \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$ to the diagonal form by transformation $C^{-1}AC$. 8

(b) What is similarity transformation ? If T is the trace of matrix, find its trace after a similarity transformation. Show that eigenvalues and eigen-functions will be affected by the similarly transformation. 8

Unit II

4. (a) Solve : 8

$$\frac{d^2y}{dx^2} - 2\tan x \frac{dy}{dx} + 3y = 2\sec x$$

(b) Solve : 8

$$(D^3 - 5D^2 + 8D - 4)y = e^{2x} + 2e^x + 3e^{-x}$$

5. (a) Find series solutions of : 8

$$x\frac{d^2y}{dx^2}+\frac{dy}{dx}+x^2y=0$$

(b) Write Hermite equation and find one sries solution. 8

Unit III

6. (a) Find the values of $J_{\pm\frac{1}{2}}(x)$. 4

(b) Prove that : 4

$$\int_{-1}^{+1}[P_n(x)]^2\,dx=\frac{2}{2n+1}$$

(c) For Hermite polynomials, show that :

(i) $2nH_{n-1}(x)=H_n'(x)$

(ii) $2xH_n(x)-H_{n-1}(x)=H_n'(x)$. 8

7. (a) Show that Legendre polynomials can be expressed as : 8

$$P_n(x)=\frac{1}{2^n n!}\frac{d^n}{dx^n}(x^2-1)^n$$

(b) Derive the orthogonality for Langmuir's polynomials. **8**

Unit IV

8. (a) Prove and explain Cauchy's integral formula. **8**

(b) Evaluate $I = \int_{-\infty}^{\infty} \frac{x \sin ax}{x^4 + 4} dx$ when $a \neq 0$. **8**

9. (a) Explain the function $f(z) = \frac{1}{z+1}$ about $z = 1$ in Taylor's series. **4**

(b) Carry out invers Laplace transform of : **4**

$$\ln\left[\frac{s^2}{s^2+4}\right]$$

(c) Expand $f(x) = \sin x$, $0 < x < \pi$, in a Fourier cosine series. **8**

No. of Printed Pages : 05 Roll No. .....

24032

M. Sc. EXAMINATION, Dec. 2018

(First Semester)

PHYSICS

18PHY21HC2

Classical Mechanics

Time : 3 *Hours*] [*Maximum Marks :* 80

Note : Attempt *Five* questions in all, selecting at least *one* question from each Unit.

1. (a) Determine the degrees of freedom of the following cases : 4

   (i) A rigid body moving freely in three dimensional spaces.

   (ii) The bob of canonical pendulum

   (iii) Simple pendulum

   (iv) Particle moving on an inside surface of a cone.

(b) Define inertia tensor. Give its physical significance. 4

(c) State Kepler's Laws of Planetary Motion. 2

(d) What are the Euler's angles ? What is the importance of these angles ? 2

(e) Write down the conditions of orbits to be closed under inverse square law of force. 2

(f) Write down two instances where Newtons laws break down and why ? 2

Unit I

2. (a) What is Hamilton's variational principle ? Drive Lagrange's equation of motion from it for conservative system ? Also drive the equation of motion for a particle of mass m falling freely under gravity near the surface of earth. 12

(b) In the following :

(i) Newtonian

(ii) Lagrangian

(iii) Hamiltonian,

which one is more fundamental approach and why ? Compare all in brief. 2

(c) What do you mean by D'Alembert Principle ? 2

3. (a) Drive the general form of Lagrangian equations from D'Alembert principle and also extent it for the conservative system. 10

(b) Obtain the equation of motion of a system of two masses, connected by an inextensible string passing over a small smooth pully. 6

Unit II

4. What is differential scattering cross-section ? Discuss the problem of scattering of charged particles by a Coulomb field and obtain Rutherford's formula for the differential scattering cross section. 16

5. (a) Drive an expression for the rotational kinetic energy of a rigid body. **10**

(b) A particle describes a circular orbit given by $r = 2a\cos\theta$. Under the influence of an attractive central force directed towards a point on the circle. Show that the force varies as the inverse fifth power of the distance. **6**

Unit III

6. Define Principle of Least Action. Also prove that for a conservative system for which the Hamiltonian H is conserved, the principle of least action states that :

$$\Delta \int_{t_0}^{t_1} \sum_j p_j \dot{q}_j dt = 0$$

Also deduce (i) the Jacobi's form of the principle of least action (ii) arc length of the particle trajectory. **16**

7. State and prove Hamilton's Jacobi equation for Hamilton's principle Function and explain how it can be used to solve Kepler's problem for a particle in an inverse square central force field. **16**

Unit IV

8. (a) Explain stable and unstable equilibrium. **4**

   (b) Consider a linear triatomic molecule consisting of two atoms of mass 'm' placed symmetrically on each side of 'M'. Obtain the normal modes and normal frequencies of small amplitude oscillation of such a molecule. **12**

9. (a) Prove that $[X, Y]_{q, p} = [X, Y]_{Q, P}$. **8**

   (b) Using Poisson bracket prove that :

   $[l_x, l_y] = l_z$, $[l_y, l_z] = l_x$, $[l_z, l_x] = l_y$

   where l_z, l_x, l_y are angular momentum. **8**

No. of Printed Pages : 04 Roll No. .....

24033

M. Sc. EXAMINATION, Dec. 2018

(First Semester)

PHYSICS

Quantum Mechanics

Time : 3 Hours] [*Maximum Marks : 70*

Note : Attempt *Five* questions in all, selecting *one* question from each Unit. Q. No. 1 is compulsory. All questions carry equal marks.

1. (a) What is Ehrenfest theorem ?

(b) What do you mean by Hermitian operators ? Show that the product of two Hermitian operators F and G is self-adjoint if F and G commute ?

(c) Calculate the possible values of quantum numbers j and m for hydrogen atom in the ground state and in the 2p-state ?

(d) Write down the Pauli theory of electron spin. 4×4=16

Unit I

2. (a) What is Young's double slit experiment ? How it explains wave particle duality ? **8**

(b) Find out the ground state energy of a particle confined in one dimensional box of length L using uncertainty relation. **8**

3. (a) What do you understand by degeneracy ? Also discuss Ortho-normality of Eigen functions ? **8**

(b) Write down Physical and Statistical interpretation of wavefunction. **8**

Unit II

4. (a) Write down the Schrödinger equation for linear harmonic oscillator and find out the energy eigen values. 8

   (b) What is Hilbert Space ? 8

5. (a) What are coherent states ? Write down the concept of time evolution of coherent states. 8

   (b) What is the concept of Unitary Transformations ? 8

Unit III

6. (a) Represent the orbital angular momentum in terms of Spherical polar coordinates. 8

   (b) What is Stem-Gerlach experiment ? 8

7. (a) What are Electron Spin Operators ? Also write down the Pauli spinmatrices. 8

   (b) What are the Recursion relations for the C-G coefficients ? 8

Unit IV

8. (a) Obtain the expectation value of r in the ground state of hydrogen atom. **8**

   (b) Obtain an expression for density of states. **8**

9. (a) Drive an expression for the allowed energy of the three dimensional harmonic oscillator. Obtain the wave function also. **8**

   (b) Discuss quantum theory of free electrons. **8**

Unit I

2. (a) Explain what is meant by mobility of a charge carrier in a solid. Derive an expression for the conductivity of a semi-conductor containing both free electrons and holes in terms of concentration n and p and the mobility μ_n and μ_p. **10**

   (b) Explain V-I characteristics of Solar Cell. **6**

3. (a) Derive the expression for diffusion capacitance and show that diffusion capacitance is directly proportional to diode current. **10**

   (b) Derive an expression for p-n junction volt-ampere equation. **6**

Unit II

4. (a) What is meant by fixed bias of a transistor ? Give its advatnages and disadvantages. **8**

(b) For a silicon transistor with $\beta = 100$ biased with resistor method, draw load line and determine operating points. Given $V_{cc} = 8V$, $R_b = 730\ k\Omega$ and $R_c = 2\ k\Omega$. **8**

5. (a) Compare the construction design and V-I characteristics of enhancement and depletion mode *n*MOSFET. **10**

(b) With the following reading obtained experimentally from a FET : **6**

V_{GS}	:	– 0.1 V	– 0.1 V	0.4 V
V_{DS}	:	5V	14V	14V
I_D	:	8mA	8.3 mA	7.1 mA

Determine :

(i) A.C. drain resistance

(ii) Transconductance

(iii) Amplification factor.

Unit III

6. (a) What is the maximum power transfer theorem ? Show that power lost in the itnernal generator is equal to the power delivered to the load and the power efficiency is only 50%. **10**

(b) State Thevenin's theorem and prove it in case of two terminal networks. 6

7. (a) What is a Two-Port Device ? Discuss various h-parameters of transistor for CE configuration. 10

(b) Explain Kirchhoff's current law. 6

Unit IV

8. (a) Draw electronic equivalent circuit for the following quadratic differential equation using Op-Amp :

$$d^2v/dt^2 + 5dv/dt - 10v = 10$$

where 'v' is a time dependent voltage source. 10

(b) Give application of Op-Amp as Logarithmic Amplifier. 6

9. (a) What is a level translator ? Why is it required in a dc differential amplifier ? 8

(b) Discuss the frequency response of band pass butterworth filter. 8