I Semester M. Sc Degree Examination

PHYSICS: Mathematical Methods for Physics

Time: 3 Hours Max. Marks: 80

Answer **all** questions

1. a) Discuss the effect of change of basis and similarity transformation.

   b) Let $e_1, e_2 ..... e_n$ be a basis of V. Then, for any linear operators $S, T \in A(V)$, $[ST]_e = [S]_e [T]_e$. (10+5)

OR

2. a) Discuss Fourier cosine (sine) transform of a derivative in detail.

   b) Obtain the Fourier transform of the Dirac function $\delta(t-a)$ (10+5)

3. a) A quantity A (p,q,r) in the coordinate system x^i_{qs}, such that A(p,q,r) $B^{qs}_r = C^s_p$ where B^{qs}_r *and* C^s_p are Tensors. Prove that A (p,q,r) is a tensor

   b) Define sum, difference and inner product of tensors. (10+5)

OR

4. a) Define Christoffel symbol of II kind and obtain the Christoffel symbol of II kind in plane polar coordinates.

   b) Express grad, div and curl in spherical polar coordinate system. (10+5)

5. a) Solve the differential equation $\frac{d^2y}{dx^2} + x\frac{dy}{dx} + (x^2+2)y = 0$ by Frobenius' method.

   b) Explain ordinary and singular points of a differential equation. (10+5)

OR

6. a) Transform a second order differential equation into an integral equation.

   b) Derive a Fredholm integral equation corresponding to $y''(x) - y'(x) = 0$ with $y(1) = 1$ *and* $y(-1) = 1$. (10+5)

7. a) Solve the Laguerre differential equation $xy'' + (1-x)y' + \lambda y = 0$ using Frobenius' method.

   b) Prove that the recurrence relation of $P_n(x)$ is given by

$n P_n(x) = (2n-1)x P_{n-1}(x) - (n-1)P_{n-2}(x)$ (10+5)

OR

8. a) Derive orthogonality relation for Bessel's functions

   b) Obtain the relationship between gamma function and beta function. (10+5)

9. Answer any **FOUR** of the following. (5 X 4=20)

   a) Prove that the eigenvalues of a unitary matrix are of modulus unity.

   b) Determine whether or not the following vectors are linearly dependent in $\mathbb{R}^3$ (1,2,1), (2,1,1) and (7,4,1).

   c) Examine the tensor nature of $\begin{bmatrix} -xy & x^2 \\ -y & xy \end{bmatrix}$.

   d) Prove that if A_p is a tensor then its covariant derivative $A_{p,q}$ is also a tensor.

   e) Check the singularity of the equation $(1-x^2)y''-2xy'+l(l+1)y=0$ at $x=+1 and\ x=-1$.

   f) Solve the integral equation $\phi(x) = x + \frac{1}{2}\int_{-1}^{-1}(t-x)\varphi(t)dt$

   g) Prove that $x L_n'(x) = nL_n(x) - nL_{n-1}(x)$

   h) Determine the value of $\Gamma\left(\frac{1}{2}\right)$

I Semester M. Sc Degree Examination

PHYSICS: Classical Mechanics

Time: 3 Hours Max. Marks: 80

Answer **all** questions

1. a) Prove that the sum of PE and KE remains constant for a system of particles moving under the action of a conservative force.
   b) Define centre of mass for a system of particles (10+5)

(OR)

2. a) Starting from D'Alembert's principle, derive an expression for Lagrange's equations of motion.
   b) What are constraints? Write their classification. (10+5)

3. a) Derive Hamilton's canonical equations of motion from variational principle.
   b) Obtain Hamiltonian for one dimensional simple harmonic oscillator. (10+5)

(OR)

4. a) Define the term 'canonical transformation' and hence derive the condition for a canonical transformation.
   b) Define Poisson bracket and express Hamilton's equation of motion using Poisson's equation. (10+5)

5. a) Using Hamilton –Jacobi method solve one dimensional harmonic oscillator problem.
   b) State and prove parallel axis theorem. (10+5)

(OR)

6. a) Set up Euler equations of motion for a rigid body.
   b) What do you mean by inertia? Explain its physical significance. (10+5)

7. a) Deduce $E^2 = p^2c^2 + m_o^2c^4$.
   b) Discuss the simultaneity in relativity. (10+5)

(OR)

8. a) Deduce Newton's gravitational theory from Einstein's field equations.

b) What is meant by principle of covariance? Differentiate between covariance and invariance. (10+5)

9. Answer any **FOUR** of the following. (5 x 4=20)

a) Check whether force $\vec{F} = (2x^2 - 5xy)\hat{i} + (3y - 4x^2)\hat{j}$ is conservative or not.

b) Obtain the equation of motion for Atwood machine.

c) Give the significance of Hamiltonian function.

d) Using Poisson brackets show that the following transformation is canonical:

$$Q = \sqrt{2q}e^t \cos p \quad \textit{and} \quad P = \sqrt{2q}e^t \sin p$$

e) Show that the kinetic energy of a rotating rigid body can be written as $T = \frac{1}{2}\omega J$

f) Calculate the inertia tensor for the system of four point masses 2g, 3g, 4g and 6g located at the points (1,0,0), (1,-1,0), (1,1,-1) and (1,-1,1).

g) At what speed does a meter stick move if its length is observed to shrink to 0.5m?

h) Describe the equivalence principle.

I Semester M. Sc Degree Examination

PHYSICS: Atomic and Molecular Physics

Time: 3 Hours Max. Marks: 80

Answer **all** questions

1. a) Obtain an expression for the rotational energy of a diatomic molecule considering rigid rotator model.
   b) Briefly explain Born –Oppenheimer approximation (10+5)

(OR)

2. a) With the help of energy level diagram, explain the rotational structure of electronic transition.
   b) Write a note on the formation of band head in rotational band spectra for $B_v^{'} < B_v^{''}$ using Fortrat parabola. (10+5)

3. a) Describe the parameters of a molecular structure in detail.
   b) Write the differences between electrovalent bond and covalent bond. (10+5)

(OR)

4. a) Based on the Valence bond theory, explain the electrical conductivity of metals and semi-metals.
   b) Briefly explain sp- hybridization along with its characteristics. (10+5)

5. a) Explain the processes of induced absorption, spontaneous emission and stimulated emission in LASERS using Einstein's coefficients.
   b) Write a note on 'coherence' in Lasers. (10+5)

(OR)

6. a) Explain the construction and working of He-Ne Laser. Mention its applications.
   b) Write the applications of Holography techniques. (10+5)

7. a) Define Harmonic generation. How second harmonic generation can be observed experimentally?
   b) Explain the environmental application of Laser Raman Spectroscopy. (10+5)

(OR)

8. a) What is mode locking of Lasers? Discuss with examples.

b) Explain Optical fiber communication briefly. (10+5)

9. Answer any **FOUR** of the following. (10+5)

a) Obtain an expression for rotational level with maximum intensity using Boltzmann distribution law.

b) Write a note on non-rigid rotator

c) Explain lattice energy along with some examples.

d) What is close packing structure? Explain in brief.

e) What do you mean by pumping in Lasers? What are its types?

f) Discuss the construction of CO_2 laser along with the neat diagram.

g) Explain why anti-Stokes' lines are less intense than Stokes' lines?

h) Write a note on the application of short pulse lasers?

I Semester M. Sc. Degree Examination

PHYSICS: Solid State Physics and Electronic Devices

Time: 3 Hours Max. Marks: 80

Answer **all** questions

1. a) State and prove Bloch theorem.
   b) Distinguish between first and second Brillouin zones. (10+5)

OR

2. a) Using Kronig-Penny model, show that energy spectrum of solids consists of number of allowed energy bands separated by forbidden gaps.
   b) Discuss a method of determining Fermi surface of a metal experimentally. (10+5)

3. a) Discuss the Sommerfeld theory of free electrons
   b) Write a note on Umklapp scattering. (10+5)

OR

4. a) Discuss electrical conductivity of metals at high frequency and obtain an expression for dielectric constant.
   b) What is Gudden-Pohl effect? Discuss. (10+5)

5. a) Obtain an expression for carrier concentration in an intrinsic semiconductor
   b) Explain the effect of doping on Fermi level in semiconductors. (10+5)

OR

6. a) Mention different mechanisms of excitation and emission processes. Derive an expression for intensity of temperature independent luminescence.
   b) Write a brief note on Destriau effect with an example. (10+5)

7. a) Discuss the formation of space charge region in a p-n junction diode and obtain an expression for the width of the region.
   b) Find the value of applied voltage at 296 K for a p-n junction diode if I_0= 35 μA/cm^2 and I_F=2.6 A/cm^2 (10+5)

OR

8. a) With a neat diagram, discuss the construction and working of a JFET.
   b) Explain the working of relaxation oscillator using UJT (10+5)

9. Answer any **FOUR** questions. (5 X 4 = 20)

a) Show that the reciprocal lattice of a b.c.c is f.c.c.

b) Discuss the importance of Fermi surfaces.

c) A photon of energy equal to double the rest mass energy of electron gets back scattered by an electron. Calculate the wavelength of scattered photon.

d) Write a note on Hall Effect and its importance.

e) In an intrinsic semiconductor at temperature of 298 K the mobility of electrons and holes are 0.4 $m^2V^{-1}s^{-1}$ and 0.22 $m^2V^{-1}s^{-1}$ respectively. Calculate its energy gap.
Given: the resistivity of the specimen =0.37Ωm.

f) Write a note on Schotky effect.

g) Obtain an expression for current, when a p-n junction is forward biased.

h) Distinguish between BJT and JFET.