SYLLABUS AND SCHEME FOR

M.Sc PHYSICS PROGRAMME- 2016

The duration of the M.Sc (Physics) programme shall be 2 years, split into 4 semesters. Each course in a semester has 4 credits (4C). Practicals having 3 credits (3C) and viva-voce having 2 credits are conducted at the end of 2nd and 4th semesters. In the Fourth Semester there are three theory courses and one project with 4 credits. The total credits for the entire programme is 80. The scheme and syllabus of the programme, consisting of sections (a)*Courses in various semesters* (b)*The Credits and Hours* (c)*Grading and Evaluation* (e)*Detailed syllabus* are as follows:

A) COURSES IN VARIOUS SEMESTERS

Semester -I (16C)

(VPPH1C01) Classical Mechanics (4C)

(VPPH1C02) Mathematical Physics - I (4C)

(VPPH1C03) Electrodynamics and Plasma Physics (4C)

(VPPH1C04) Electronics (4C)

(VPPH1P01) General Physics Practical -I

(VPPH1P02) Electronics Practical -I

Semester -II (24C)

(VPPH2C05) Quantum Mechanics -I (4C)

(VPPH2C06) Mathematical Physics -II (4C)

(VPPH2C07) Statistical Mechanics (4C)

(VPPH2C08) Computational Physics (4C)

(VPPH2P01) General Physics Practical -II (3C)

(VPPH2P02) Electronics Practical -II (3C)

External Practical Examination

VPPH1P01 & VPPH2P01, VPPH1P02 & VPPH2P02

(VPPH2 V01) Viva –Voce (2C)

Semester -III (16C)

(VPPH3C09) Quantum Mechanics -II (4C)

(VPPH3C10) Nuclear and Particle Physics (4C)

(VPPH3C11) Solid State Physics (4C)

(VPPH3E1)Elective -I (4C)

(VPPH4PR) Project

(VPPH3P03) Modern Physics Practical –I

(VPPH4P04) Computational Physics Practical-I

Semester -IV (24C)

(VPPH4C12) Spectroscopy (4C)

(VPPH4E2)Elective II (4C)

(VPPH4E3)Elective III (4C)

(VPPH4PR) Project (4C)

(VPPH4P03) Modern Physics Practical II (3C)

(VPPH4P04) Computational Physics Practical (3C)

External Practical Examination.

VPPH3P03 &VPPH4P03, VPPH3P04&VPPH4P04

(VPPH4 V02) Viva –Voce (2C)

B) CONSTITUTION OF CLUSTERS

Elective -I Cluster:

(VPPH3E11) Experimental Techniques
(VPPH3E12) Computer Applications in Physics
(VPPH3E13) Radiation Physics
(VPPH3E14) Nanostructures and characterization

Elective -II Cluster:

(VPPH4E21) Materials Science
(VPPH4E22) Advanced Condensed Matter Physics
(VPPH4E23)Physics of Semiconductors
(VPPH4E24) Lasers and Fibre Optics

Elective -III Cluster:
(VPPH4E31) Modern Optics
(VPPH4E32) Astrophysics
(VPPH4E33) Chaos and Nonlinear Physics
(VPPH4E34) Foundations of Quantum Mechanics

C) THE CREDITS AND HOURS PER WEEK

The credits and hours proposed for various courses in different semesters are as given under.

Semester	No.of Theory papers	Practicals	Theory		Practical		Project		Seminar	Viva Credit	Total Hrs	Total Credit
			Hrs	Credit	Hrs	Credit	Hrs	Credit	Hrs			
I	4	1. Gen. Phy 2. Electronics	16	16	8	0	0	0	1	0	25	16
II	4	1. Gen. Phy 2. Electronics	16	16	8	6	0	0	1	2	25	24
III	4	1. Mod. Phy 2. Comp.Phy	16	16	8	0	0	0	1	0	25	16
IV	4	1. Mod. Phy. 2. Comp.Phy.	12	12	8	6	4	4	1	2	25	24
Total Credits for the Programme												80

D) GRADING AND EVALUATION

(1) Accumulated minimum credit required for successful completion of the course shall be 80.

(2) A project work of 4 credit is compulsory and it should be done in III & IV semesters. Also a comprehensive Viva Voce may be conducted by external examiners at the end of II& IV Semester and carries 2 credits each.

(3) Evaluation and Grading

All grading starting from the evaluation of papers is done on 5 point scale (A, B, C, D, E) and SGPA and CGPA – between 0 to 4 and in two decimal points. An overall letter grade (Cumulative Grade) for the whole programme shall be awarded to the student based on the value of CGPA using a 7-point scale given below.

Overall Grade in a Programme

CGPA	*Overall Letter Grade*
3.80 to 4.00	A+
3.50 to 3.79	A
3.00 to 3.49	B+
2.50 to 2.99	B
2.00 to 2.49	C+
1.50 to 1.99	C
1.00 to 1.49	D

(4) Weightage of Internal and External valuation:

Evaluation	*Weightage*
Internal 1 (or 25%)	External 3 (or 75%)

The evaluation scheme for each course shall contain two parts (1) internal evaluation (2) external evaluation. Its weightages are as follows:

Both internal and external evaluation will be carried out using Direct Grading System

(5) Internal evaluation (must be transparent and fair):

Theory:
a) Tests- wt = 2 (at least 2 tests with 50% Problems)
b) Seminar/ assignments and Exercises-wt =1
c) Viva Voce- wt =1
d) Attendance - wt =1

Practical:
a) Tests - wt=2
b) Lab. skill/quality of their results- wt =1
c) Viva Voce- wt =1

Project:
a) Monthly progress - wt =2
b) Regularity and attendance -wt =1

c) Seminar and Viva Voce- wt =1

(6) External evaluation:
a) **Theory**: Every semester

Pattern of Question Papers

Division	Type	No.of Questions	Weightage	Total Weightage
Part A	Short Answer	12(No choice)	1	12
Part B	Essay	2 out of 4	6	12
Part C	Problems	4 out of 6	3	12
Total Weightage for a question paper				36

Answer to each question may be evaluated base don
a) Idea/knowledge : wt=1
b) Logic/steps: wt=1
c) Analysis skill: wt=1
d) Correctness: wt=1

b) **Practicals** : At the end of II and IV semesters
c) **Viva-voce** : At the end of IInd & IVth semesters
d) **Project** : End of IV the semester.Its evaluation is based on:
a) Presentation : wt=3
b) Project Report: wt=2
c) Project Viva: wt=1

7) Theory Papers must contain at least 4 lectures plus 1 Tutorial. Project is equal to one theory paper

8) Directions for Question paper setters
Part A: Each question to be answered in 5 minutes duration and should extract the knowledge acquired by the candidate
Part B: 30 minutes question. May be as a single question or in parts. Derivation type can be included
Part C : 15 minutes question. As far as possible avoid numerical type question.

E) DETAILED SYLLABUS

SEMESTER – I

VPPH1C01 : CLASSICAL MECHANICS (4C)

1. Lagrangian and Hamiltonian Formulation:

Constraints and Generalized coordinates, D'Alemberts principle and Lagrange"s equation, Velocity dependent potentials, Simple applications, Hamilton"s Principle, Lagrange"s equation from Hamilton"s principle, Kepler problem, Scattering in a central force field, Transformation to lab coordinates, Legendre Transformation , Hamilton"s canonical equations, Principle of least action, Canonical transformations, examples, Enough exercises **(17 hours)**

Text : Goldstein, Sections 1.3 – 1.6, 2.1 – 2.3, 3.10, 3.11, 8.1, 8.5, 8.6, 9.1, 9.2

2. The classical background of quantum mechanics:

Equations of canonical transformations, Examples, Poisson brackets and other canonical invariants, Equation of motion in Poisson bracket form, Angular momentum Poisson brackets, Hamilton-Jacobi equation, Hamilton"s principal and characteristic function, H-J equation for the linear harmonic oscillator, Separation of variables, Action-angle variables, H-J formulation of the Kepler problem, H-J equation and the Schrödinger equation, Enough exercises. **(18 hours)**

Text : Goldstein, Sections 9.1, 9.2, 9.4 - 9.6, 10.1 – 10.5, 10.7, 10.8

3. The Kinematics and Dynamics of Rigid Bodies:

Space-fixed and body-fixed systems of coordinates, Description of rigid body motion in terms of direction cosines and Euler angles, Infinitesimal rotation, Rate of change of a vector, Centrifugal and Coriolis forces, Moment of inertia tensor, Euler"s equation of motion, Force free motion of a rigid body, Enough exercises. **(14 hours)**

Text : Goldstein, Sections 4.1, 4.4, 4.8 – 4.10

4. Small Oscillations:

Formulation of the problem, Eigen value equation, Eigenvectors and Eigenvalues, Orthogonality, Principal axis transformation, Frequencies of free vibrations, Normal coordinates, Free vibrations of a linear tri atomic molecule, Enough exercises. **(9 hours)**

Text : Goldstein, Sections 6.1 – 6.4

5. Nonlinear Equations and Chaos:

Introduction, Singular points of trajectories, Nonlinear oscillations, Limitcycles, Chaos : Logistic map, Definitions, Fixed points, Period doubling, Universality, Enough exercises. **(14 hours)**

Text : Bhatia, Sections10.1, 10.2, 10.3, 10.4, 10.5, 10.51

Text Books :

1. Goldstein "Classical Mechanics" (Addison Wesley)
2. V.B.Bhatia : "Classical Mechanics" (Narosa Publications, 1997
3. Gupta, Kumar, Sarma. "Classical mechanics" (Pragati 2012)

Reference :

1. Michael Tabor : "Chaos and Integrability in Nonlinear Dynamics" (Wiley, 1989)
2. N.C.Rana and P.S.Joag : "Classical Mechanics" (Tata McGraw Hill)
3. R.G.Takwale and P.S.Puranik : "Introduction to Classical Mechanics" (Tata McGraw Hill)
4. Atam P. Arya : "Introduction to Classical Mechanics, (2nd Edition)" (Addison Wesley1998)
5. Laxmana : "Nonlinear Dynamics" (Springer Verlag, 2001)

For further reference: Classical Physics Video Prof. V. Balakrishnan IIT Madras
http://nptel.iitm.ac.in/video.php?subjectId=122106027
Special Topics in Classical Mechanics Video Prof. P.C. Deshmukh IIT Madras
http://nptel.iitm.ac.in/courses/115106068/5
Physics I - Oscillations & Waves Video Prof. S. Bharadwaj IIT Kharagpur
http://nptel.iitm.ac.in/video.php?subjectId=122105023
Chaos, Fractals & Dynamic Systems Video Prof. S. Banerjee IIT Kharagpur
http://nptel.iitm.ac.in/video.php?subjectId=108105054

VPPH1C02 : MATHEMATICAL PHYSICS – I (4C)

1. Vectors

Coordinate transformations, Differential vector operators, Vector integration, Orthogonal curvilinear coordinates, Gradient, Divergence, Curl and Laplacian operator in curvilinear coordinates, Rectangular, cylindrical and spherical polar coordinates, Enough exercises. **(12 hours)**

Text : Arfken, Weber and Harris, "Mathematical methods for Physicists", 7th edition, Academic Press (Chapter 3)

2. Matrices and Tensors

Orthogonal, Hermitian and Unitary matrices, Similarity and unitary transformations, Eigenvalue equations - Cayley-Hamilton, Hermitian operators and their properties, Diagonalization of matrices, Definition of Tensors, Contraction, Direct products, quotient rule, Pseudo tensors, Dual tensors, Levi Cevita symbol, Enough exercises **(10 hours)**

Text : Arfken, Weber and Harris, "Mathematical methods for Physicists", 7th edition, Academic Press (Chapter 2, 4 & 6)

A.W. Joshi "Matrices and tensors in Physics", 3rd edition, New Age International Publishers (Chapter 17)

3. Second Order Differential Equations

Singular points, Series solution - Frobenius method, Linear independence of solutions, A second solution, Self adjoint differential equation, Gram-Schmidt orthogonalization, Completeness of functions, Enough exercises **(12 hours)**

Text : Arfken, Weber and Harris, "Mathematical methods for Physicists", 7th edition, Academic Press (Chapter 5, 7 & 8)

4. Special functions

Gamma function, Beta function, Delta function, Dirac delta function, Bessel functions of the first and second kinds, Generating function, Recurrence relation, Orthogonality, Neumann function, Spherical Bessel function, Legendre polynomials, Generating function, Recurrence relation, Rodrigues' formula, Orthogonality, Associated Legendre polynomials, Spherical harmonics, Hermite polynomials, Laguerre polynomials, Enough exercises **(26 hours)**

Text : Arfken, Weber and Harris, "Mathematical methods for Physicists", 7th edition, Academic Press (Chapter 13, 14, 15 & 18)

5. Calculus of Variations

Euler equation, alternate forms and applications, Generalization to One dependent and one independent variable, Several dependent and independent variables, Lagrangian Multipliers, Variation with constraints, Rayleigh-Ritz variational technique **(12 hours)**

Text : Arfken, Weber and Harris, "Mathematical methods for Physicists", 7th edition, Academic Press (Chapter 22)

Reference books :

1. G.B. Arfken and H.J. Weber, Mathematical Methods for Physicists, 5th edition, Academic Press.
2. J. Mathews and R.L. Walker, Mathematical Methods for Physics, 2nd edition, Pearson education.
3. L.I. Pipes and L.R. Harvill, Applied Mathematics for Engineers and Physicists, 3rd edition, McGraw Hill.
4. Mary L Boas, Mathematical methods in the physical sciences, 2nd edition, John Wiley & Sons.
5. William E. Boyce, Richard C. DiPrima, Elementary Differential Equations and boundary value problems, John Wiley & Sons, Inc.

6. Tulsi Dass and S K Sharma, Mathematical methods in Classical and Quantum Physics, Universities Press.
7. Suresh Chandra and Mohit Kumar Sharma, "An Introduction to Mathematical Physics", Narosa Publishing House

For further reference:

Mathematics I Video Prof. Swagato K. Ray,Prof. Shobha Madan,Dr. P. Shunmugaraj
http://nptel.iitm.ac.in/video.php?subjectId=122104017
Mathematics II Video Prof. Sunita Gakkhar, Prof. H.G. Sharma, Dr. Tanuja Srivastava IIT Roorkee
http://nptel.iitm.ac.in/video.php?subjectId=122107036
Mathematics III Video Prof. P.N. Agrawal, Dr. Tanuja Srivastava IIT Roorkee
http://nptel.iitm.ac.in/video.php?subjectId=122107037

VPPH1C03: ELECTRODYNAMICS (4C)

1. Time varying fields and Maxwell's equations :

Maxwell"s equations, Potential functions, Electromagnetic boundary conditions, Wave equations and their solutions, Time harmonic fields, Enough exercises. **(10 hours)**

Text : David K Cheng , Chapter 7

2. Plane electromagnetic waves :

Plane waves in lossless media, Plane waves in lossy media, Group velocity, Flow of electromagnetic power and the Poynting vector, Normal incidence at a plane conducting boundary, Oblique incidence at a plane conducting boundary, Normal incidence at a plane dielectric boundary, Oblique incidence at a plane dielectric boundary Enough exercises. **(15 hours)**

Text : David K Cheng , Chapter 8

3. Transmission lines, Wave guides and cavity resonators:

Transverse electromagnetic waves along a parallel plane transmission line, General transmission line equations, Wave characteristics on finite transmission lines, General wave behaviour along uniform guiding structures, Rectangular wave guides, Cavity resonators (Qualitative ideas only), Enough exercises. **(15 hours)**

Text : David K Cheng, Chapter 9,10

4. Relativistic electrodynamics :

Magnetism as a relativistic phenomenon, Transformation of the field, Electric field of a point charge moving uniformly, Electromagnetic field tensor, Electrodynamics in tensor notation, Potential formulation of relativistic electrodynamics, , Enough exercises. **(16 hours)**

Text : David J Griffiths, Chapter 10

5. Plasma and Radiation Physics

Plasma - Definition, concepts of plasma parameter, Debye shielding, Motion of charged particles in an electromagnetic field - Uniform electric and magnetic fields, Plasma oscillations, Multipole expansion, Dipole radiation-Electric dipole radiation, Magnetic dipole radiation Enough exercises.
(16 hours)

Text : Chen, Chapter1,2 , David J Griffith- Chapter 3,11

Text Books :

1. David K. Cheng : " Field and Wave Electromagnetics" (Addisson Wesley)
2. David Griffiths : " Introductory Electrodynamics" (Prentice Hall of India, 1989)
3. F. F. Chen, Introduction to Plasma Physics and Controlled Fusion, Volume I and II, Plenum Press, recent edition

Reference books :

1. K.L. Goswami, Introduction to Plasma Physics – Central Book House, Calcutta

2. J.D.Jackson : "Classical Electrodynamics" (3rd Ed.) (Wiley,1999)

VPPH1C04: ELECTRONICS (4C)

1. Field Effect Transistor :

Biasing of FET, Small signal model, Analysis of Common Source and Common Drain amplifier, High frequency response, FET as VVR and its applications, Digital MOSFET circuits, Enough exercises. **(12 hours)**

Text : Millman and Halkias : "Integrated Electronics" (Tata McGraw Hill 2002) Chapter 10

Reference : Electronic devices and circuit theory, Robert L Boylstead & L. Nashelsky – Pearson Education (fifth Edition)

2. Operational Amplifier : .

Basic operational amplifier characteristics, OPAMP differential amplifier, Emitter coupled differential amplifier, OPAMP parameters (Open loop gain, CMRR, Input offset current and voltage, output offset voltage, slew rate) and their measurement, Frequency response, Principle of Bode plots, Phase and gain margins, Dominant pole, pole zero and lead compensation, Enough exercises **(12 hours)**

Text : Millman and Halkias : "Integrated Electronics" (Tata McGraw Hill 2002), Chapter 15

3. OPAMP Application : .

OPAMP as inverter, scale changer, summer, V to I converter, Analog integration and differentiation, Electronic analog computation, Active low pass filter, High pass Butterworth filters, Band pass filter, Active resonant band pass filter, OPAMP based astable and monostable multivibrators, Schmidt trigger, Enough exercises **(14 hours)**

Text : Millman and Halkias : "Integrated Electronics" (Tata McGraw Hill 2002), Chapter 16

Reference :1. Ramakant A. Gaekwad : "OPAMPS and Linear Integrated Circuits"

2. D. Roychoudhuri : "Linear Integrated circuits" – New Age International Publishers (1997)

4. Digital Electronics :

Minimization of functions using Karnaugh map, Representation using logic gates, JK and MSJK flip-flops, Synchronous and asynchronous counters, MOD 3,5,10,16 counters, Cascade counters, Static and dynamic random access memory, CMOS, Non-volatile NMOS, Magnetic memories, Charge coupled devices, Enough exercises **(16 hours)**

Text: 1. Fundamentals of Microprocessors and Micro Computers"– B. Ram

5. Microprocessors and Microcontrollers

Organization of microcomputers, microprocessor as CPU, Organization and internal architecture of the Intel 8085, instruction set, Assembler Programming. Examples of Assembly Language Programming: Addition, Subtraction of two 8 bit & 16 bit numbers, One's compliment, Two's compliment, Shifting of 8 bit& 16 bit numbers, Square from Lookup table, Largest and Smallest in a data array, sorting of numbers in ascending and descending order, 8 bit multiplication and division, Overview of 8051 microcontroller; Inside 8051; 8051 register and stack, Enough exercises. **(18 hours)**

Text: Microprocessors 1.Micrpprocessor Architecture Programming and applications. Ramesh S Gaonkar 2.Introduction to Microprocessors–A.P. Mathur (Tata-McGraw Hill). 3. Fundamentals of Microprocessors and Micro Computers"– B. Ram, Chapter: 1, 3

Text :Microcontrollers: 1. Microcontrollers & Embedded systems by Muhammed Ali Mazidi & Janice Guillespie Mazidi(Prentice Hall) 2. Introduction to Microprocessors –A.P. Mathur (Tata-McGraw Hill).

Text Books:
1. Malvino and Leach: "Digital Principles and Applications(3nd Ed.)" (Tata McGraw Hill, 1978)
2. R.P. Jain : "Modern Digital Electronics" (Tata McGraw Hill)) Chapter 11 (For charge coupled devices)
3. B. Ram : "Fundamentals of Microprocessors and Microcomputers)

Reference:
1. M.S. Tyagi ; "Introduction to Semiconductor Devices" (Wiley)
2. Millman and Halkias : "Integrated Electronics"
3. Gupta and Kumar : "Handbook of Electronics"

For further reference: Electronics Video Prof. D.C. Dube IIT Delhi
http://nptel.iitm.ac.in/courses/115102014/
Digital Integrated Circuits Video Prof. Amitava Dasgupta IIT Madras
http://nptel.iitm.ac.in/video.php?subjectId=108106069

SEMESTER – II

VPPH2C05: QUANTUM MECHANICS-I (4C)

1. The Formulation of Quantum Mechanics:

Vector spaces, The Hilbert space, Dimensions and basis, Operators and properties, Representation of vectors and operators, Commutator, Functions of operators, Eigen values and eigen vectors, Matrix representation of bras, kets and operators, Coordinate and momentum representations and their connection, The fundamental postulates Probability density, Superposition principle, Observables and operators, The uncertainty principle **(14 hours)**

Texts: Quantum Mechanics V. K.Thankappan, Chapter 2 &3

2. Quantum Dynamics:

The equation of motion, Schrodinger, Heisenberg and the Interaction pictures of time development, The linear harmonic oscillator in the Schroedinger and Heisenberg pictures, Abstract operator method, Hydrogen atom **(12 hours)**

Texts : Quantum Mechanics V K.Thankappan , Chapter 4 and P.M Mathews & K. Venkatesan chapter 4

3. Theory of Angular Momentum:

Angular momentum operators, Matrix representation of angular momentum operators, Pauli spin matrices, Orbital angular momentum, The hydrogen atom, Addition of angular momenta , Clebsh-Gordon coefficients, Simple examples **(16 hours)**

Texts : Quantum Mechanics V K.Thankappan, Chapter 5

4. Symmetry and Conservation Laws :

Space-time symmetries, Space translation and conservation of linear momentum, Time translation and conservation of energy, Space rotation and conservation of angular momentum, Space inversion and time reversal, Identical particles, Construction of symmetric and anti symmetric wave functions, Slater determinant, Pauli exclusion principle, Bosons and Fermions, Spin wave functions for two electrons **(12hours)**

Texts : Quantum Mechanics V K.Thankappan, Chapter 6

5. Scattering:

a)Scattering cross section: General considerations, kinematics of scattering process : differential and total cross- section: wave mechanical picture of scattering ;the scattering amplitude Green"s functions; formal expression for scattering amplitude. **b)**:The born approximations, Validity of the born approximations ,The born series, **c)**Partial Wave Analysis: Asymptotic behavior of partial waves; phase shifts ,the scattering amplitude in terms of phase shifts, the differential and total cross - section: optical theorem, phase shifts: Relation to the potential, potential of finite range, low energy scattering. **d)** Exactly Soluble Problems: scattering by a square well potential, scattering by a hard sphere . **e)**Yukawa potential. Enough exercises. **(18 hours)**

Text : P.M Mathews & K. Venkatesan Chapter 6, V K. Thankappan Chapter 7

Text books :

1.V.K. Thankappan : "Quantum Mechanics" Third edition.(Wiley Eastern)
2.N. Zettili, "Quantum Mechanics – Concepts and applications" (John Wiley & Sons, 2004)
3.P.M.Mathews and K.Venkatesan : "A Textbook of Quantum Mechanics" (Tata McGraw Hill)

Reference books :

1. N. Zettili, "Quantum Mechanics – Concepts and applications" (John Wiley & Sons, 2004)
2. L..I.Schiff : "Quantum Mechanics" (McGraw Hill)
3. P.M.Mathews and K.Venkatesan : "A Textbook of Quantum Mechanics" (Tata McGraw Hill)
4. A.Messiah : "Quantum Mechanics"
5. J.J.Sakurai : "Modern Quantum Mechanics" (Addison Wesley)
6. Stephen Gasiorowics : "Quantum Physics"
7. A.Ghatak and S.Lokanathan : "Quantum Mechanics" (Macmillan)
8. V. Devanathan : "Quantum Mechanics " (Narosa, 2005)

For further reference:

Quantum Physics Video Prof. V. Balakrishnan IIT Madras
http://nptel.iitm.ac.in/video.php?subjectId=122106034
Quantum Mechanics and Applications Video Prof. Ajoy Ghatak IIT Delhi
http://nptel.iitm.ac.in/courses/115102023

VPPH2C06: MATHEMATICAL PHYSICS-II (4C)

1. Functions of Complex Variables

Complex variables and functions, Analyticity, Cauchy-Reimann conditions, Cauchy's integral theorem and integral formula, Laurent expansion, Singularities, Calculus of residues and evaluation of definite integrals and complex exponentials **(18 hours)**

Text : Arfken, Weber and Harris, 7th edition, Academic Press (Chapter 11)

2. Group Theory

Groups, multiplication table, conjugate elements and classes, subgroups, direct product groups, isomorphism and homomorphism, permutation groups, distinct groups of given order, Schur's lemma, orthogonality and character tables, Reducible and irreducible representations, generators of continuous groups, rotation groups SO(2) and SO(3), , SU(2)-SO(3) homomorphism, SU(2) isospin and SU(3) eightfoldway **(18 hours)**

Text : A.W. Joshi, Elements of Group theory for Physicists, 4th edition, New Age International (P).Ltd.
Arfken, Weber and Harris, 7th edition, Academic Press (Chapter)

3. Fourier Series

Fourier series, periodic functions, applications of Fourier series, Fourier integral, Fourier transform, Properties, Inverse Fourier transform, Transform of the derivative, Convolution theorem, Laplace transform, Properties, Enough exercises. **(16 hours)**

Text : Arfken, Weber and Harris, 7th edition, Academic Press (Chapter 19 & 20)

4. Green's function

Green's function, 1-dimensional Green's function, Green's function integral-differential equation, Symmetry, eigenfunction expansion, Enough exercises **(10 hours)**

Text : Arfken, Weber and Harris, 7th edition, Academic Press (Chapter 10)

5. Integral equations:

Integral equations - Integral transforms and generating functions, Neumann series, Separable kernel **(10 hours)**

Text : Arfken, Weber and Harris, 7th edition, Academic Press (Chapter 21)

Reference books :

1. G.B. Arfken and H.J. Weber, Mathematical Methods for Physicists, 5th edition, Academic Press.
2. J. Mathews and R.L. Walker, Mathematical Methods for Physics, 2nd edition, Pearson education.
3. William E. Boyce, Richard C. DiPrima, Elementary Differential Equations and boundary value problems, John Wiley & Sons, Inc.
4. Tulsi Dass and S K Sharma, Mathematical methods in Classical and Quantum Physics, Universities Press.
5. Donald A McQuarrie, Mathematical methods for Scientists and Engineers, Viva books.
6. P.K. Chattopadhyay, Mathematical Physics, 2nd edition, New Age International (P).Ltd.

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Mathematics II Video Prof. Sunita Gakkhar, Prof. H.G. Sharma, Dr. Tanuja Srivastava IIT Roorkee
http://nptel.iitm.ac.in/video.php?subjectId=122107036
Mathematics III Video Prof. P.N. Agrawal, Dr. Tanuja Srivastava IIT Roorkee
http://nptel.iitm.ac.in/video.php?subjectId=122107037

VPPH2C07: STATISTICAL MECHANICS (4C)

1. The Statistical Basis of Thermodynamics:

The macroscopic and the microscopic states – Contact between statistics and Thermodynamics: Expressing T, P and μ in terms of Ω – The classical Ideal gas - The entropy of mixing and the Gibbs paradox, The correct enumeration of microstates - Phase space of a classical system - Liouville"s theorem and its consequences. **(14 hours)**

Text : Pathria, Sections 1.1 – 1.6, 2.1 – 2.2

2. Microcanonical, Canonical and Grand Canonical Ensembles:

The microcanonical ensemble – Examples : (1) Classical Ideal gas, (2) Linear harmonic oscillator -Quantum states and the phase space – Equilibrium between a system and a heat reservoir- Physical significance of the various statistical quantities in the canonical ensemble- Alternative expressions for the partition function- Examples: (1) The classical systems: Ideal gas, (2) A system of harmonic oscillators, (3) The statistics of paramagnetism - Energy fluctuations in the canonical ensemble -Equipartition theorem - Virial theorem - Equilibrium between a system and a particle-energy reservoir- Physical significance of the various statistical quantities in the grand canonical ensemble- Example : Classical Ideal gas - Density and energy fluctuations in the grand canonical ensemble. **(20 hours)**

Text : Pathria, Sections 2.3 -2.5, 3.1, 3.3 - 3.9, 4.1, 4.3 – 4.5

3. Formulation of Quantum Statistics:

Quantum-mechanical ensemble theory: The density matrix- Statistics of the various ensembles- Example: An electron in a magnetic field - Systems composed of indistinguishable particles- An ideal gas in a quantum-mechanical microcanonical ensemble- An ideal gas in other quantum-mechanical ensembles- Statistics of the occupation numbers **(16 hours)**

Text : Pathria, Sections 5.1 - 5.4, 6.1 – 6.3

4. Ideal Bose Systems:

Thermodynamic behaviour of an ideal Bose gas- Thermodynamics of the blackbody radiation- The field of sound waves. **(12 hours)**

Text : Pathria, Sections : 7.1 - 7.3

5. Ideal Fermi Systems:

Thermodynamic behaviour of an ideal Fermi gas- Magnetic behaviour of an ideal Fermi Gas : (1) Pauli paramagnetism, (2) Landau diamagnetism – The electron gas in metals (Discussion of heat capacity only), Enough exercises. **(10 hours)**

Text : Pathria, Sections : 8.1 - 8.3

Text Book:

1. Statistical Mechanics (2nd Edition), R. K. Pathria , Butterworth-Heinemann / Elsevier (1996)

Reference Books:

1. Statistical Mechanics : An Elementary Outline, Avijit Lahiri, Universities Press (2008)
2. An Introductory Course of Statistical Mechanics, Palash. B. Pal, Narosa (2008)
3. Statistical Mechanics : An Introduction, Evelyn Guha, Narosa (2008)
4. Statistical and Thermal Physics : An Introduction, S. Lokanathan and R.S.Gambhir, Prentice Hall of India (2000).
5. Introductory Statistical Mechanics (2nd Edition), Roger Bowley and Mariana Sanchez, Oxford University Press (2007)
6. Concepts in Thermal Physics, Stephen. J. Blundell and Katherine. M. Blundell, Oxford University Press (2008)
7. An Introduction to Thermal Physics, Daniel. V. Schroeder, Pearson (2006)
8. Statistical Mechanics, Donald. A. McQuarrie, Viva Books (2005)
9. Problems and Solutions on Thermodynamics and Statistical Mechanics, Ed. by Yung – Kuo Lim, Sarat Book House (2001)

VPPH2C08: COMPUTATIONAL PHYSICS (4C)

1. Introduction to Python language:

Inputs and Output methods, Variables, operators, expressions and statements, Strings, Lists, list functions and methods (len, append, insert, del, remove, reverse, sort, +, *, max, min, count, in, not in, sum), sets, set functions and methods(set, add, remove, in, not in, union, intersection, symmetric difference)- Tuples and Dictionaries, Conditionals, Iteration and looping - Functions and Modules - File input and file output, Exercises. **(14 hours)**

Ref: (1) Python for Education, Ajith Kumar B.P., (2) Python tutorials available on the net (http://www.altaway.com/resources/python/tutorial.pdf)

2. Numpy module-Arrays and Matrices:

Creation of arrays and matrices (arrange, linspace, zeros, ones, random, reshape, copying arrays), Arithmetic Operations, cross product, dot product , Saving and Restoring, Matrix inversion, solution of simultaneous equations(use functions in linalg module),Exercises. **(14 hours)**

Ref: Guide to NumPy, Travis E. Oliphant

3. Data visualization-The Matplotlib, Module:

Methods defined in matplotlib, Plotting graphs, Multiple plots, Polar plots-, Pie Charts, Plotting Sine, Log, Exponential, Bessel, Legendre, Gaussian and Gamma functions. Parametric plots, Exercises. **(14 hours)**

Ref: Matplotlib for python developers, Sandro Tosi

4. Numerical methods:

Least –square curve fitting Procedure-Linear and non linear, Solution of Algebraic and Transcendental equations- The Bisection method and Newton –Raphson method- Numerical solution of ordinary differential equations- Runge Kutta methods-Boundary value problems, Finite –difference method, The shooting method Inverse of a function , Monte Carlo Methods (Basic ideas): simple integration **(15 hours)**

Ref: 1. Numerical Recipes in C, W.H.Press, S.A.Teukolsky et al.
2. Introductory methods of numerical analysis, S.S. Shastry , (Prentice Hall of India,1983)

5. Introduction to Computational approach in Physics*:

Formulation: from Analytical methods to Numerical Methods - Oscillatory motion – Ideal Simple Harmonic Oscillator (Euler method), Driven LCR circuit (R-K method), circuit analysis using Kirchoff‟s laws, central field motion, simulations of standing waves, Monte-Carlo simulations- value of π, simulation of radioactivity, Logistic maps, enough exercises. **(15 hours)**

(*Programs are to be discussed in Python, Visualisation can be done with matplotlib/pylab)

Text book: Computational Physics-An Introduction, R.C.Verma, P.K.Ahluwalia & K.C.Sharma, New Age International Publishers

Reference: Computational Physics, V.K.Mittal, R.C.Verma & S.C.Gupta, Ane‟s Student Edition.

More References:

(For *Python any book can be used as reference. Moreover a number of open articles are available freely in internet. Python is included in default in all GNU/Linux platforms and it is freely downloadable for Windows platform as well. However use of GNU/Linux may be encouraged).*

1. www.python.org
2. Python Essential Reference, David M. Beazley, Pearson Education
3. Core Python Programming, Wesley J Chun, Pearson Education
4. Python Tutorial Release 2.6.1 by Guido van Rossum, Fred L. Drake, Jr., editor. This Tutorial can be obtained from website http://www.altaway.com/resources/python/tutorial.pdf
5. How to Think Like a Computer Scientist: Learning with Python, Allen Downey , Jeffrey Elkner , Chris Meyers, http://www.greenteapress.com/thinkpython/thinkpython.pdf
6. Numerical Recipes in C, second Edition(1992), Cambridge University Press
7. Numerical Recipes in Fortran 77, second Edition(1992), Cambridge University Press
8. Numpy reference guide, http://docs.scipy.org/doc/numpy/numpy-ref.pdf (and other free resources available on net)
9. Matplotlib , http://matplotlib.sf.net/Matplotlib.pdf (and other free resources available on net)
10. Numerical Methods, E Balagurusamy, Tata McGraw-Hill
11. Numerical Methods , T Veerarajan, T Ramachandran, Tat MCGraw-Hill
12. Numerical Methods with Programs I BASIC, Fortran & Pascal, S Balachandra Rao, C K Shantha. Universities Press
13. Numerical methods for scientists and engineers, K. Sankara Rao, PHI
14. Numerical Methods in Engineering with Python by Jaan Kiusalaas

Practical for Semester I & II

a) VPPH1P01 &VPPH2P01 (GENERAL PHYSICS)

Note :
1. All the experiments should involve error analysis. Internal evaluation to be done in the respective semesters and grades to be intimated to the controller at the end of each semester itself. Practical observation book to be submitted to the examiners at the time of examination.
2. Eight experiments are to be done by a student in a semester. One mark is to be deducted from internal marks for each experiment not done by the student if the required total of experiments are not done in the semesters.

(At least 16 experiments should be done, 8 each for I & II semesters)

1. Y and σ - Interference method (a) elliptical (b) hyperbolic fringes. To determine Y and σ of the material of the given specimen by observing the elliptical and hyperbolic fringes formed in an interference set up
2. Y and σ by Koenig's method
3. Variation of surface tension with temperature – Jaegar's method. To determine the surface tension of water at different temperatures by Jaegar‟s method of observing the air bubble diameter at the instant of bursting inside water
4. Thermal conductivity of liquid and air by Lee's disc method.
5. Viscosity of a liquid - Oscillating disc method. To determine the viscosity of the given liquid by measurements on the time period of oscillation of the disc in air and in the liquid
6. Mode constants of a vibrating strip. To determine the first and second mode constants of a steel vibrating strip; Y to be measured by the Cantilever method and frequency of vibration by the Melde's string method
7. Constants of a thermocouple and temperature of inversion.
8. Maxwell's L/C bridge -To determine the resistance and inductance of the given unknown inductor by Maxwell's L/C bridge OR Anderson‟s Bridge – L/C and self inductance.

9. Susceptibility measurement by Quincke's and Guoy's methods - Paramagnetic susceptibility of salt and specimen
10. Michelson's interferometer - (a) λ and (b) dλ
11. Photoelectric effect - Determination of Planck's constant
12. Franck Hertz experiment .To measure the ionization potential of Mercury by drawing current versus applied voltage.
13. Fabry Perot etalon - Determination of thickness of air film.
14. Elementary experiments using Laser (a) Study of Gaussian nature of laser beam (b) Evaluation of beam spot size (c) Measurement of divergence (d) Diameter of a thin wire
15. Diffraction Experiments using lasers (a) Diffraction by single slit/double slit/circular aperture (b) Diffraction by reflection grating
16. Measurement of the thermal and electrical conductivity of Cu to determine the Lorentz number
17. Passive filters
18. Cauchy's constants using liquid prism
19. Forbe's method of determining thermal conductivity
20. Zeeman effect setup – measurement of Bohr magnetron
21. Characteristic of a thermistor - Determination of the thermistor parameters
22. Dipole moment of an organic molecule (acetone).
23. Determination of Fermi energy of Copper
24. Study of LED characteristics - Determination of wavelength of emission, I-V characteristics and variation with temperature, variation of output power vs. applied voltage

Reference Books:

1. B.L. Worsnop and H.T. Flint - Advanced Practical Physics for students - Methusen & Co (1950)
2. E.V. Smith - Manual of experiments in applied Physics - Butterworth (1970)
3. R.A. Dunlap - Experimental Physics - Modern methods - Oxford University Press (1988)
4. D. Malacara (ed) - Methods of experimental Physics - series of volumes - Academic Press Inc. (1988)
5. S.P. Singh –Advanced Practical Physics – Vol I & II – Pragati Prakasan, Meerut (2003) – 13th Edition

b) VPPH1P02 &VPPH2P02 (ELECTRONICS)
(At least 16 experiments should be done, 8 each for I & II semesters.)

1. UJT characteristics and application as a relaxation oscillator & sharp pulse generator. Use of UJT in a time delay circuit.
2. Voltage Regulation using transistors with feedback (regulation characteristics with load for different input voltages and variation of ripple % with load) study of load and line regulation characteristics.
3. Single stage RC coupled Negative feedback amplifier(input, output résistance, frequency response with & without feedback)
4. Two stage RC coupled amplifier; study of input, output impedances & power gain.
5. Common source FET amplifier - frequency response, input &output impedance.
6. Differential amplifier using transistors; study of I/O impedances, frequency response & CMRR.
7. Design of Amplitude modulation circuit. Detection using diodes. Determination of modulation index & recovery of modulating signal.
8. Darlington pair amplifier; study of gain, frequency response, input & output impedances.
9. Basic configurations of OPAMP IC 741 – Inverting, Non-inverting and Difference amplifiers: design and construction for specified gain; study of bode-plots.
10. Design and construction of Wien bridge oscillator using OPAMP for different frequencies.
11. Design and construction of astable and monostable multivibrators using OPAMPS.
12. Design and construction of Sawtooth generator using transistors/OPAMP for different frequencies.
13. IC 555 Timer – Astable & Monostable multivibrators,Voltage control oscillator, Saw tooth generator, Frequency modulator for sinusoidal signal.

14. Two stage IF amplifier; study of the performance of single stage and coupled stages.
15. Schmidt triggers using OPAMPS – for symmetrical and non-symmetrical LTP/UTP. Trace hysteresis curve.
16. Analog integration and differentiation using OPAMPS; study the integrator and differentiator characteristics.
17. Second order Butterworth Low pass, High Pass and Band Pass filters using OPAMP – study of frequency response.
18. Bootstrap Amplifier; study of frequency response, input & output impedance.
19. 4 bit D/A converter using R-2R ladder network. Realization of 4 bit A/D converter using D/A converter.
20. Study of 4 bit binary counter (IC 7493) and 4 bit decade counter(IC 7490) at various modes. Use of counters as frequency dividers.
21. Minimization of a three variable truth table using Karnaugh map and realization using NAND gates.
22. Microprocessors experiments; addition, subtraction, division and multiplication of 1 byte numbers using Intel 8085 kit.

Reference Books :

1. Paul B. Zhar and A.P. Malvino - Basic Electronics - A Text Book Manual – JMH publishing (1983)
2. A.P. Malvino - Basic Electronics - A text lab manual - Tata McGraw Hill (1992)
3. R. Bogart and J. Brown -Experiments for electronic devices and circuits – Merrill International series (1985)
4. Buchla - Digital Experiments - Merrill International series (1984)
5. S.P. Singh – Pragati Advanced Practical Physics – Vol I & II – Pragati Prakasan Meerut (2003) – 13th Edition

For further reference:

Basic Electronics and Lab Video Prof. T.S. Natarajan IIT Madras
http://nptel.iitm.ac.in/video.php?subjectId=122106025

SEMESTER - III

VPPH3C09: QUANTUM MECHANICS –II (4C)

1. Approximation methods for time-independent problems:

The WKB approximation, connection formulae, bound state verification of Bohr-Somerfeld old quantum theory, Penetration of a potential barrier. Time-independent perturbation theory, Non-degenerate and degenerate cases, Anharmonic oscillator, stark and Zeeman effects in hydrogen.

(18 hours)

Text: Thankappan, Chapter 8

2. Variational method:

The variational equation, ground state and excited states, application to ground state of the hydrogen and Helium atoms. **(8 hours)**

Text: V.K.Thankappan, Chapter 8

3. Time dependent perturbation theory:

Transition probability, Harmonic perturbation, Interaction of an atom with the electromagnetic field, Induced emission and absorption,The dipole approximation, Enough exercises. **(14 hours)**

Text: V.K.Thankappan, Chapter 8

4. Relativistic Quantum Mechanics:

The Dirac equation, Dirac matrices, Solution of the free-particle Dirac equation, The Dirac equation with potentialls, Equation of continuity, Spin of the electron, Non-realistic limit, spin-orbit coupling, Hole theory, The Weyl equation. The Klein Gordon equation, Charge and current densities, The Klein-Gordon equation with potentials. **(20 hours).**

Text: V.K.Thankappan Chapter 10

5. Quantization of fields:

The principles of canonical quantization of fields, Lagrangian density and Hamiltonian density, Second quantization of the Schrödinger wave field for bosons and fermions,Enough exercises.

(12 hours.)

Text: V.K.Thankappan Chapter 11

Textbooks:

1. V.K. Thankappan: "Quantum Mechanics", Second edition (Wiley Eastern)
2. N.Zettili, "Quantum Mechanics – Concepts and applications" (John Wiley & Sons, 2004)
3. G.Aruldas, Quantum Mechanics, Second Edition, PHI learning Pvt Ltd (2009)
4. P.M Mathews and Venkatesan, "A Textbook of Quantum Mechanics" (Tata McGraw Hill)
5. J.D. Bjorken and D. Drell: "Relativistic Quantum Fields" (McGraw Hill 1998)

Reference books:

1. L.I. Schiff: Quantum Mechanics" (McGraw Hill)
2. J.J. Sakurai: "Advanced Quantum Mechanics" (Addison Wesley)
3. Stephen Gasiorowicz: "Quantum Physics"
4. D.J.Griffiths, *Introduction to Quantum Mechanics*, Second Edition, Pearson Education, Inc (2005)
5. L.H.Ryder, Quantum Field Theory, Second Edition, Cambridge University Press (1996)
6. Field Quantization,Greiner and Reinhardt (Spinger-Verlag -1996)

For further reference:

Relativistic Quantum Mechanics Video Prof. Apoorva D Patel IISc Bangalore
http://nptel.iitm.ac.in/courses/115108074/

VPPH3C10 : NUCLEAR AND PARTICLE PHYSICS (4C)

1. Basic properties of nuclei and study of nuclear force:

Nuclear size, shape, mass and binding energy, semi empirical mass formula, Angular momentum and parity, nuclear electromagnetic moments, characteristics of nuclear force, the deuteron, nucleon-nucleon scattering the exchange force model. **(14 hours).**

Texts: Introductory Nuclear Physics by Kenneth S Krane) Chapter: - 3, 4
Reference: (1) Introduction to Nuclear Physics by Harald Enge
(2) Nuclear Physics by Roy & Nigam

2. Nuclear Models:

The shell model, shell model potential, spin-orbit potential, magnetic dipole moments, electric quadruple moments, valence nucleons, Even Z-even N nucleii and collective structure. **(12 hours).**

Text: Kenneth S Krane- Chapter 5
Reference: Harald Enge and Roy & Nigam

3. Nuclear Decays:

Beta decay, Energy release in beta decay, Fermi theory of beta decay, Experimental tests of the Fermi theory, angular momentum and parity selection rules, parity violation in beta decay. Energetics of gamma decay, classical electromagnetic radiation, transition to quantum mechanics, angular momentum and parity selection rules, Internal conversion. **(14 hours).**

Text: Kenneth S Krane- Chapter 9, 10
Reference: Harald Enge and Roy & Nigam

4. Nuclear Reactions, Fission and Fusion:

Types of reactions and conservation laws, Energetics of nuclear reactions, reaction cross sections, compound nucleus reactions, Nuclear fission, characteristics of fission, energy in fission, Nuclear fusion: basic fusion processes, characteristics of fusion, solar fusion. **(14 hours).**

Text: Kenneth S Krane - Chapter 11, 13, 14
References: Harald Enge and Roy & Nigam

5. Particle Physics

Basic forces and classification of particles: The four basic forces, The force of gravity, the electromagnetic force, the week force and electroweak theory, the strong force. Conservations laws: Conservation laws and symmetries, conservation of energy and mass, conservation of linear momentum, conservation of angular momentum, conservation of electric charge, conservation of baryon and lepton numbers, conservation of strangeness, conservation of isospin and its components, the TCP theorem, conservation of parity. Quark model: The eightfold way, discovery of omega minus, the quark model, the confined quarks, experimental evidences for quark model, coloured quarks, quantum chromodynamics and gluons, particle interactions and Feynman diagrams Enough exercises.. **(18 hours).**

Text: 1.The particle Hunters - Yuval Neeman & Yoram Kirsh Chapter : 6, 7, 9
2. https://teachers.web.cern.ch/teachers/archiv/HST2002/feynman/
3. Introduction to Elementary Particles-David Griffiths Sections :

References:

1. Introductory nuclear Physics by Samuel S.M. Wong, Chapter 2
2. Introduction to Elementary Particles-David Griffiths.

For further reference:
Nuclear Physics: Fundamentals and Applications Video Prof. H.C. Verma IIT Kanpur
http://nptel.iitm.ac.in/courses/115104043/

VPPH3C11: SOLID STATE PHYSICS (4C)

1. Crystal Structure, binding and Lattice Vibrations:

Reciprocal lattice, description of X-ray diffraction using reciprocal lattice, Brillouin zones, Vander Waals interaction, Cohesive energy of inert gas crystals, Madelung interaction, Cohesive energy of ionic crystals, Covalent bonding, Metallic bonding, Hydrogen-bonded crystals. Vibrations of monatomic and diatomic lattices, Quantization of lattice vibrations, Inelastic scattering of neutrons, Einstein and Debye models of specific heat, Thermal conductivity, Effect of imperfection**.** **(14 hours)**

Texts: C.Kittel (Relevant sections of chapters-1,2,3,4 and 5)

2. Electron States and Semiconductors:

Free electron gas in three dimensions, Specific heat of metals, Sommerfield theory of electrical conductivity, Wiedemann-Franz law, Hall effect, Nearly free electron model and formation of energy bands, Bloch functions, Kronig Penny model, Formation of energy gap at Brillouin zone boundaries, Number of orbitals in a band, Equation of motion of electrons in energy bands, Properties of holes, Effective mass of carriers, Intrinsic carrier concentration, Hydrogenic model of donor and acceptor states. Direct band gap and indirect band gap semiconductors **(18 hours)**

Texts: C.Kittel(Relevant sections of chapters-6,7,8,9)

3. Dielectric, Ferroelectric and magnetic properties:

Theory of Dielectrics: polarization, Dielectric constant, Local Electric field, Dielectric polarisability, Polarisation from Dipole orientation, Ferroelectric crystals, Order-disorder type of ferroelectrics, Properties of $BaTiO_3$, Polarisation catastrophe, Displasive type ferroelectrics, Landau theory of ferroelectric phase transitions, Ferroelectric domain, Antiferroelectricity, Piezoelectricity, Applications of Piezoelectric Crystals, Diamagnetism and Paramagnetism: Langevin's theory of diamagnetism, Langevin's theory of paramagnetism, theory of Atomic magnetic moment, Hund's rule, Ferro, Anti and Ferri magnetism: Weiss theory of ferromagnetism, Ferromagnetic domains, Neel Model of Antiferromagnetism and Ferrimagnetism, Spinwaves, Magnons in Ferromagnets (qualitative) **(20 hours)**

Texts: C.Kittel(chapters-13,14,15)

4. Superconductivity:

Meissner effect, Type I and Type II superconductors, energy gap Isotope effect, London equation and penetration of magnetic field, Cooper pairs and the B C S ground state (qualitative, Flux quantization, Single particle tunnelling, DC and AC Josephson effects, High Tc Superconductors(qualitative) description of cuprates, Enough exercises. **(10 hours)**

Texts: C.Kittel(chapter-12)

5. Solid state Devices:

Radiative transitions and optical absorption, Light emitting diodes (LED) –Semiconductor solid state lasers, Photodetectors - photoconductor (Light dependent resistor- LDR) and photodiode, p-n junction solar cells - short circuit current, fill factor and efficiency, Enough exercises. **(10 hours)**
Text: "Semiconductor Devices- Physics and Technology" - S.M.Sze, John Wiley and Sons (2002) second edition(Relevant sections of chapters 8 and 9).

Text Books:
1. C.Kittel: Introduction to Solid State Physics 7th edition (Wiley India)
2. A.J.Dekker: Solid State Physics (Macmillian 1958)
3.R.K.Puri and V.K. Babbar:Solid State Physics and Electronics(S. Chand Publisher, 2004)
4.M.A.Wahab:Solid State Physics: Structure and Properties of Materials(Narosa, 2009)
5.S.M.Sze: Semiconductor Devices- Physics and Technology, John Wiley and Sons (2002)
Reference Books:
1. M.Ali Omar, Elementary Solid State Physics, Addison-Wesley Publishing Company
2. N.W.Ashcroft and Mermin: Solid State Physics (Brooks Cole (1976)
3. Elements of Solid State Physics, Srivastava J.P. Prentice Hall of India (2nd edn.)
4. Ziman J.H. Principles of Theory of Solids - (Cambridge 1964)
5. Luth – Solid State Physics.
6.S.O.Pillai- Solid State Physics. (New Age International Pvt Ltd Publishers)
7.J.P Srivastava-Elements of Solid state Physics (PHI; 3 edition 2011)

ELECTIVE I- A

VPPH3E11: EXPERIMENTAL TECHNIQUES (4C)

Unit I - Vacuum Science and Technology

Production of Vacuum- Basic definitions and units, Expression for Pumping speed, Different vacuum regimes, Knudsen number, Classification of vacuum Pumps, Construction and working of Oil sealed rotary vane pump, Diffusion Pump,Turbo molecular Pump, Sorption Pump, Gettering Pump, Sputter-ion Pump, and Cryogenic Pump. Pressure Measurement in Vacuum Systems- Classification of Gauges, Mechanical Gauges-Bourdon Gauge and diaphragm Gauge, Liquid manometers-Open - ended and Closed- ended U-tube manometers. Pirani gauge, Penning gauge, Thermocouple gauge, Hot and Cold Cathode ionization gauges.Vacuum Accessories – Vacuum Valves -Diaphragm valve, Gate valve, Butterfly valve, Baffle and isolation valves, magnetic valves, adjustable valves, air inlet valves, Traps - Liquid nitrogen trap, Sorption traps, Flanges, Gaskets and O- Rings, Bellows, Couplings.

(16 hours)

Text Books:
1. Vacuum Science and Technology, V.V. Rao, T.B. Ghosh, K.L. Chopra (Allied Publishers Limited,New Delhi)
2. Advanced Experimental Techniques in Modern Physics, K.M.Varier, Antony Joseph, P.P.Pradyumnan,(Pragati Prakshan, Meerut)
Reference Books:
1. Basic Vacuum Technology, B.S. Halliday, A.Chambers, (Overseas Press India Limited)
2. High Vacuum Techniques -Theory and Practice, J.Yarwood (Chapman and Hall Limited)

Unit – II Techniques for synthesis of Thin films and nanomaterials

Introduction, Nature and Applications of thin films, Distribution of deposit, Knudsen Cosine law Thermal Deposition Techniques-Resistive Heating, Flash Evaporation, Exploding wire, Electron Beam evaporation, Laser Evaporation, Arc Evaporation techniques Sputter Deposition Technique- Sputtering theory, Sputtering yield, Different parameters controlling sputter yield, Cathodic sputtering, Glow Discharge sputtering, Variables influencing glow discharge sputter deposition._Growth techniques of nanomaterials- Top-down Vs. Bottom-up technique-Lithographic process and itslimitations, Nonlithographic techniques-Ball milling , Chemical vapour deposition, solgel techniques ,molecular beam epitaxy-Other processes. **(12 hours)**

Text Books:

1. Thin film fundamentals, A. Goswami, (New Age International Publishers, New Delhi)
2. Advanced Experimental Techniques in Modern Physics, K.M.Varier, Antony Joseph, P.P.Pradyumnan,(Pragati Prakshan, Meerut)
3. Introduction to Nanoscience & Technology - K.K.Chathopadhyay, A.N.Banerjee (Prentice-Hall of India -2011.)

Reference Books:

1. Thin film phenomena – K.L. Chopra, (Mc Graw Hill International)
2. Text Book of Optics, Brijlal, Subrahmaniam, Avadhanulu (S-Chand Company)
3. Materials Science and Processes – S.K. Hajra Choudhury (Indian Book Publishing Co.-2009)
4 .Nanotechnology - Richard Booker, Earl Boysen (Wiley Publishing Inc. 2005).

Unit – III Cryogenic techniques:

Introduction, Review of history, General techniques of Liquefaction of gases – Internal and external work methods, Adiabatic Expansion, Joule-Kelvin effect, Isenthalpic curve, Inversion curve, Regenerative cooling. Liquefiers- Linde‟s Air Liquefier, Dewar‟s Hydrogen liquefier, Kammerlingh Onne's helium Liquefier, Uses of Liquefied gases, Special properties of Liquid Helium-Super fluidity, Lambda point-HeliumI and Helium II.Maintenance of Cryogenic Temperatures – Dewar flask, Henning cryostat, Hydrogen vapour cryostat.

Production of Sub Kelvin Temperatures - Adiabatic Demagnetization of Paramagnetic Salts (working and thermodynamic equations), Nuclear Adiabatic demagnetization to produce micro Kelvin temperatures, He3-He4 Dilution Refrigerator, Magnetic Refrigerator. Measurement of low temperatures - Primary and Secondary Thermometers, Gas thermometers and corrections, Resistance thermometers, (Relevant equations),Vapour pressure thermometer, Thermo-Electric thermometers, Magnetic Thermometer. **(18 hours)**

Text Books:

1. Matter and Methods at Low Temperatures (Frank Pobell, Springer-Verlag,Third Indian Edition,)
2. Advanced Experimental Techniques in Modern Physics, K.M.Varier, Antony Joseph, P.P.Pradyumnan,(Pragati Prakshan, Meerut)

Reference Books:

1. Heat, Thermodynamics and Statistical Physics, Brijlal, Subrahmanyam, Hemne, (S-Chand and Company, New Delhi, 2010 Multi coloured edition)
2. Heat and Thermodynamics by Zemansky and Dittman (Tata Mc Graw Hill)
3. Low temperature Physics, L.C.Jackson (John Wiley & Sons)

Unit – IV Charged Particle Accelerator techniques:

DC accelerators- General set up of an accelerator installation, Cock-Croft Walton accelerator, Van de Graff accelerator, Tandem Van de Graff accelerator, Pelletron. AC accelerators- Construction and working principles of Linear accelerator, Cyclotron, Sector focussed cyclotron, Synchrocyclotron, principle of phase stability, Microtron, Betatron, Electron and Proton Synchrotron, Particle smashers (Colliders)qualitative idea only. Ion sources – Ionization processes, simple ion source, Duoplasmatron, RF ion source, important applications of accelerators, and Major accelerator installations in India (general awareness). **(12 hours)**

Text Books:

1. Nuclear and Particle Physics, S. Kakani, Shubhra Kakani, (VIVA Books New Delhi)
2. Introduction to Nuclear and Particle Physics,(Chapter 6) V.K.Mittal, R.C.Verma (PHI Learning Private Limited, New Delhi)

Reference Books:

1. An Introduction to Particle accelerators, E.J.N. Wilson, (Oxford University Press, ISBN 0-19-850829
2. Advanced Experimental Techniques in Modern Physics, K.M.Varier, Antony Joseph, P.P.Pradyumnan,(Pragati Prakshan, Meerut)
3. Nuclear Physics, S.N. Ghoshal, (S. Chand & Company Ltd, New Delhi)

Unit – V Analytical Techniques for thin films and nanomaterials:

Thin film Thickness Measurement- On line and off line measurement, Mechanical techniques-Microbalance and Quartz Crystal Oscillator methods, Electrical techniques-Wheatstone"s Bridge method, Collinear Four-Probe method, Optical Techniques-Photometric, Spectro photometric, Interferometric methods Charaterisation .

XRD Technique - Introduction, Lattice planes and Bragg"s Law, Diffractometer-Instrumentation, Single crystal and Powder diffraction, Scherrer equation, Debye-Scherrer Camera, Applications of XRD (qualitative ideas only), Awareness on Powder Diffraction File (PDF) of the International Centre for Diffraction Data.

Analytical techniques: DTA, TGA and DSC techniques, Atomic force microscope, Magnetic force microscope, High resolution transmission electron microscope, Optical UV-Vis-NIR, Luminescence measurements , EDAX, XPS. **(14 hours)**

Text Books:

1. Advanced Experimental Techniques in Modern Physics, K.M.Varier, Antony Joseph, P.P. Pradyumnan,(Pragati Prakshan, Meerut)
2. Solid State Physics, N.W.Ashcroft, N.D.Mermin (Thomson Book India Ltd, 2006 Edition) for XRD.
3. Elements of X-ray Diffraction by B D Cullitty(Addison Wesley, Califoria)
4. Solid State Physics and electronics, R K Puri and V K Babbar. S Chand & Company
5. Introduction to Nanoscience & Technology "- K.K.Chathopadhyay, A.N.Banerjee (Prentice-Hall of India -2011.)

Reference Books-

1. Nuclear Physics – Principles and Applications, J.S. Lilley, (John Wiley & Son Ltd, Indian Edition)
2. Useful Link for XRD-http://pd.chem.ucl.ac.uk/pdnn/powintro/whatdiff.htm
3. Useful link for Analytical Tachniques: http://en.wikipedia.org/wiki/thermal analysis
4. Useful link http://itc.tu-bs.de/Abteilungen/makro/methods/DSC.pdf

ELECTIVE 1 B

VPPH3E12 -COMPUTER APPLICATIONS IN PHYSICS

Unit I

Introduction to MATLAB

MATLAB environment – working with data sets – data input/output –logical variables and operators – array and X-Y Plotting – simple graphics –data types matrix, string, cell and structure – manipulating of data of different types – file input –output – matlab files – simple programs.**(18 hours)**

Unit II

MATLAB Tools

Signal processing – toolbox – digital and analog filter design – spectral analysis – filtering and discrete FFTs – Z-transform – DFT and FFT – MATLAB tools for wavelet transform – instrument control toolbox – partial differential equation toolbox – finite element method. **(18hours)**

Unit III

Introduction to LABView

Introduction – palette, controls & functions palette – data types, conversion. Front Panel: Construction, containers, decorations, vi properties, tabs – parallel data flow, create indicators/ controls/ constants indicators, controls – math operations, booleans, arrays, case structures, sequences – for loops, while loops, shift registers, clusters. **(18 hours)**

Unit IV

Interfacing with LABView

Error handling, bundle/unbundle sub VI'S **-** I/O: reading and writing to files, paths, data taking, charting, graphing timing function, timed loops, event structures signal generation/processing, waveform types, dynamic data, Fourier analysis – connecting to hardware – DAQ, Serial, GPIB, TCP/IP and USB interface. **(18 hours)**

Reference Books

1. Introduction to Matlab, R.L. Spencer & M. Ware, Brigham Young University (2010).
2. Learning MATLAB, The Math Works, Inc (1999).
3. Digital Signal Processing Using Matlab, V.K. Lngle & J.G. Proakis, PWS Publishing Company (1997).
4. Digital Image Processing Using MATLAB, R.C. Gonzalez, R.E. Woods, & S. L. Eddins, Prentice-Hall (2003).
5. LabVIEW Basics I Course Manual, National Instruments Corporation.
6. Electronics with LabVIEW, Kenneth L. Ashley, Analog Pearson Education (2003).
7. Applications of Numerical Techniques with C, Suresh Chandra, Narosa (2006).

ELECTIVE 1 C
VPPH3E13: RADIATION PHYSICS

1. Radiation source :

Types of radiations, ionizing, non ionizing, electromagnetic, particles, neutral -gamma-neutrinoneutron, charged alpha, beta, gamma, and heavy ion sources, radioactive sources – naturally occurring production of artificial isotopes, accelerators–cyclotrons, nuclear reactors. **(12 hours)**
{Ref 1, 2}

2. Interaction of radiations with matter :

Electrons – classical theory of inelastic collisions with atomic electrons, energy loss per ion pair by primary and secondary ionization, specific energy loss, bremsstrahlung, range energy relation, energy and range straggling Heavy charged particles – stopping power, energy loss, range and range – energy relations, Bragg curve, specific ionization, Gamma rays – Interaction mechanism – Photoelectric absorption, Compton scattering, Pair production, gamma ray attenuation, attenuation coefficients, Elastic and inelastic scattering, Cross sections, linear and mass absorption coefficients, stopping power, LET,Neutrons – General properties, fast neutron interactions, slowing down and moderation.**(17 hours)**
Ref 1,2}

3. Radiation quantities, Units and Dosimeters :

Particle flux and fluence, calculation of energy flux and fluence, curie, Becquerel, exposure and its measurements, absorbed dose and its relation to exposure, KERMA, Biological effectiveness, wighting factors, (WR and WT), Equivalent dose, Effective dose, Dosimeters, Primary and secondary dosimeters, Pocket osimeter, Films and solid dosimeter (TLD and RPL), Clinical and calorimetric devices , Radiation survey meter for area monitoring. **(15 hours)**
{Ref 2,3}

4. Biological effects :

Basic concepts of cell biology, Effects of ionizing radiations at molecular, sub molecular and cellular levels, secondary effects, free radicals, deterministic effects, stochastic effects,,, Effects on tissues and organs, genetic effects, Mutation and chromosomal aberrations, applications in cancer therapy, food preservation, radiation and sterilization **(12 hours)**

{Ref 3,4}

5. Radiation protection, shielding and transport :

Effective radiation protection, need to safeguard against continuing radiation exposure, justification and responsibility, ALARA, concept of radiologic practice. time distance and shielding, safety specifications. method of radiation control, Shielding factor for radiations, Choice of material, Primary and secondary radiations, Source geometry, Beta shielding, Gamma shielding, neutron shielding, Shielding requirements for medical, industrial and research facilities, handling of the source, sealing, transport and storage of sealed and unsealed sources. records, spills. waste disposal, Enough exercises. **(16 hours)**

{Ref 3,4,5}

Reference Books :

1. G.F.Knoll, Radiation detection and measurement, John Wiley & sons, Newyork, (2000)
2. K.Thayalan, Basic radiological physics, Jaypee brothers medical Publishers, New Delhi, (2003)
3. W.J. Meredith and J.B. Masse, Fundamental Physics of radiology, Varghese publishing house , Bombay (1992)
4. M.A.S. Sherer, P.J.Visconti, E.R Ritenour, Radiation Protection in medical radiography, Mosbey Elsevier,(2006)
5. Lowenthal G.C and Airey P.L., Practical applications of radioactivity and nuclear radiation sources, Cambridge University Press (2005)

ELECTIVE 1 D

VPPH3E14 :NANOSTRUCTURES AND CHARACTERIZATION

Unit I

Low Dimensional Structures

Preparation of quantum nanostructures - size and dimensionality effects - size effects - potential wells - partial confinement - conduction electrons and dimensionality - Fermi gas and density of states - properties dependent on density of states - excitons - single-electron tunneling - applications -infrared detectors - quantum dot lasers - superconductivity.

Microelectromechanical Systems (MEMS) - Nanoelectromechanical Systems (NEMS) – Fabrication of nanodevices and nanomachines - Molecular and Supramolecular Switches. **(18 hours)**

Unit II

Carbon Nanostructures

Carbon Molecules - Nature of the Carbon Bond - New Carbon Structures - Carbon Clusters - Small Carbon Clusters - Carbon Nano tubes - Fabrication - Structure – Electrical Properties - Vibrational Properties – Mechanical Properties - Applications of Carbon Nano Tubes - Computers - Fuel Cells - Chemical Sensors - Catalysis – Mechanical Reinforcement - Field Emission and Shielding. Solid Disordered Nanostructures - Methods of Synthesis - Failure Mechanisms of Conventional Grain sized Materials – Mechanical Properties – Nano structured Multi layers -Electrical Properties - Porous Silicon - Metal Nano cluster - Composite Glasses. **(18 hours)**

Unit III

Thermal, Microscopic and Infrared Analysis

Thermal analysis – DTA, DSC and TGA – methodology of DTA, DSC and TGA and Instrumentation.

Microscopy – Electron microscopy – Principles and instrumentation – resolution limit – scanning tunnelling microscopy – principles – scanning tunnelling microscope - SEM & TEM. Atomic force microscope – Instrumentation. IR spectrophotometers – Theory and Instrumentation- Applications. Fourier transform techniques – FTIR principles and instrumentation. Raman spectroscopy – Principles, Instrumentation and Applications. Microwave Spectroscopy -Instrumentation and Applications **(18 hours)**

Unit IV

Mass Spectrometry, Resonance Spectroscopy

Mass Spectrometry - Principle – Instrumentation – Types of ions produced in a Mass spectrometer - Interpretation of Mass spectra – Applications. NMR – Principles and Instrumentation – Chemical shift - Spin-spin coupling - Applications of NMR - Electron spin resonance spectrometry – Theory of ESR –Instrumentation - Interpretation of ESR spectra - Applications. **(18 hours)**

Reference Books:

1. Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley, (2003)
2. MEMS/NEMS: micro electro mechanical systems/nano electro mechanical systems Volume 1, Design Methods, Cornelius T. Leondes, Springer, (2006).
3. Instrumental methods of Chemical Analysis, G. Chatwal & Sham Anand, Himalaya
4. Introduction to Infrared and Raman spectroscopy, Norman D Colthup, Lawrence H Daly and Stephen E Wiberley, Academic press, NY.
5. Instrumental methods of analysis, H.H. Willard, L.L. Merrit, J.A. Dean & F.A. Settle, CBS Pub.
6. Principles of Instrumental analysis, Skoog and West – Hall – Sanders Int.
7. Instrumental methods of chemical analysis, G W Ewing, MGH
8. Scanning Tunnelling Microscopy, R. Wiesendanger & H.J. Guntherodt, Springer
9. Thermal Analysis, Wesley W.M. Wendlandt , Wiley.

SEMESTER IV

VPPH4C12: SPECTROSCOPY (4C)

1. Atomic Spectroscopy:

Spinning of electron and Vector Atom model, normal order of fine structure doublets, Electron spin-orbit interaction energy in one electron systems, spin-orbit interaction for non penetrating orbits, spin-orbit interaction for penetrating orbits, L S coupling & J J coupling, Zeeman effect, the vector model of one electron system in a Weak magnetic field, Magnetic moment of a bound electron, magnetic interaction energy and selection rules, Paschen-Back effect- Paschen-Back effect of a principal series doublet (one electron system only). Atom models for two valence electrons, coupling schemes, interaction energy for LS coupling, Lande interval rule and j-j coupling. Hyperfine structure and Lande interval rule, Nuclear interaction with one valence electron. Stark effect, Stark effect of hydrogen, Weak and strong field effect in hydrogen atom. **(20 hours)**

Text: Chapter 8, Chapter 10, Chapter 12, Chapter 13, Chapter 18 & Chapter 20.Introduction to atomic spectra by H E White

2. Microwave and Infrared spectroscopy:

Microwave Spectroscopy:The spectrum of non rigid rotator, e.g. of HF, spectrum of symmetric top molecule e.g. of CH3Cl,Instrumentation for Microwave Spectroscopy Stark Modulator, Information derived from Rotational Spectrum:

IR Spectroscopy: Born –Oppenheimer approximation, Effect of Breakdown of Born Oppenheimer approximation, Normal modes and vibration of H_2O and CO_2. Instrumentation for I R Spectroscopy – Fourier transformation I R Spectroscopy **(12 hours)**

Text: Chapter 6&Chapter 7:Molecular structure and Spectroscopy by G.Aruldas

3. Raman Spectroscopy:

Rotational Raman Spectrum of Symmetric top molecules, e.g. of $CHCl_3$ Vibrational raman Spectra, Combined use of Raman &IR Spectroscopy in structure determination e.g. of CO_2 and NO_3. Instrumentation for Raman Spectroscopy, Non-linear Raman effects, Hyper Raman effect, stimulated Raman effect CARS , PARS and Inverse Raman Effect **(12 hours)**

Text : Chapters 8 &Chapter 15 Molecular structure and Spectroscopy by G.Aruldas

4. Electronic Spectroscopy of molecules:

Vibrational Analysis of band systems, Deslander‟s table, Progressions & sequences, Information Derived from vibrational analysis, Franck Condon Principle. Rotational fine structure and P R and R Branches, Fortrat Diagram, Dissociation Energy, Example of Iodine molecule **(14 hours)**

Text: Chapter 9 Molecular structure and Spectroscopy by G.Aruldas

5. Spin Resonance Spectroscopy:

Interaction of nuclear spin and magnetic field, level population Larmour precession, Resonance Conditions, Bloch equations, Relaxation times, Spin-spin and spin lattice relaxation. The chemical shift, Instrumentation for NMR spectroscopy, Electron Spin Spectroscopy of the unpaired e, Total Hamiltonian, Fine structure, Electron Nucleus coupling, and hyperfine spectrum ESR spectrometer. Mossbauer Spectroscopy, Resonance fluroscence of γ-rays, Recoilless emission of γ-rays and Mossbauer effect, Chemical shift, effect of magnetic field. Eg. of Fe^{57} Experimental techniques, Enough exercises.

(14 hours)

Text: Chapter 10, Chapter 11 & Chapter 13. Molecular structure and Spectroscopy by G.Aruldas

References:

1. Straughan and Walker Spectroscopy Volume I, II and III
2. S K Dogra & H S Randhawa, Atomic and molecular Spectroscopy
3. G.M.Barrow – Introduction to Molecular Spectroscopy
4. H.H. Willard, Instrumental Methods of Analysis,7th Edition , CBS-Publishers, New Delhi.
5. Atomic Spectroscopy –K P Rajappan Nair ,MJP Publishers, Chennai
6. Elements of spectroscopy Gupta &Kumar –Pragati Prakasan ,Meerut

ELECTIVE –II A

VPPH4E21: MATERIALS SCIENCE

1. Crystal Imperfections

Point imperfections- The geometry of dislocations- Other properties of dislocations- Surface imperfections . **(8 Hours)**

Textbook :"Materials Science and Engineering – A First Course" – IVth Edition- V.Raghavan(Prentice-Hall of India- 1988) (Relevant sections of Chapter 6)

2. Phase Diagrams and Diffusion in Solids

The phase rule- Single component system- Binary phase diagrams- The Lever rule- Some typical phase diagrams and applications .Fick"s law and solutions- Applications based on the second law solution- The Kirkendall effect- The atomic model of diffusion- Other diffusion processes. **(14 Hours)**

Text book:" Materials Science and Engineering – A First Course" – IVth Edition- V.Raghavan (Prentice-Hall of India- 1988) **(**Relevant sections of Chapter 7 and 8)

3. Plastic Deformation and Fracture of Materials

The tensile stress- Strain curve- Plastic deformation by slip- Shear strength of perfect and real crystals- The stress to move a dislocation- Dislocation multiplication-Work hardening- The effect of grain size and precipitate particles on dislocation motion- Mechanism of creep. Ductile fracture- Brittle fracture- Fatigue fracture- Methods of protection against fracture**.** **(14 Hours)**

Text book:" Materials Science and Engineering – A First Course" – IVth Edition- V.Raghavan (Prentice-Hall of India- 1988) **(**Relevant sections of Chapter 11 and 12)

4. Engineering Materials- Polymers and Ceramic Materials

Giant molecules-Linear polymers- Three dimensional polymers-Deformation of plastics-Electrical behavior of polymers-Stability of polymers .Ceramic phases- Silicate structures- Glasses- Electromagnetic behavior of ceramics- Mechanical behavior of ceramic materials. **(18 Hours)**

Text book : " Elements of Materials Science" – IIIrd Edition – Lawrence H. Van Vlack (Addison-Wesley Publishing Company Inc. 1964.) (Relevant sections of Chapter 7 and 8)

5. Engineering NanomaterialsandNanostructures

Nano materials and Quantum mechanics.-Three dimensional Systems(bulk materials)- two dimensional systems(films)-one dimensional systems(quantum wires)-Zero dimensional systems(quantum dots)- Energy levels of quantum dots. Low dimensional structures. Quantum well, Quantum wire and Quantum dots. Nanotubes and Nanowires (Carbon Nanostructures- CNTs, Graphene) Quantum electronic devices-

Single electron Transistor, Spintronics –Giant Magnetoresistance-Spin valve structures, Microelectromechanical Systems (MEMS) - Nanoelectromechanical Systems (NEMS) .**(18 Hours)**

Text book: Nano technology-Principles and fundamentals: Ed G nter ũ Schmid, Wiley .” Introduction to Nanoscience and Nanotechnology”- K.K. Chattopadhyay and A.N. Banerjee (PHI Learning Pvt . Ltd- 2014)Encyclopedia of Nanoscience and Nanotechnology Ed.: Hari Singh Nalwa American Scientific Publishers, 2004.

References:

1. “Solid State Physics” - A.J.Dekker (MacMillan India Ltd.- 1958)
2. “Principles of the Solid State” - H. V.Keer(Wiley Eastern – 1993)
3. “Solid State Physics: Structure and Properties of Materials” - M.A.Wahab(Narosa- 2007).
4. “Materials Science and Processes” – S.K. HajraChoudhury(Indian Book Publishing Co.-2009)
6. “Nanotechnology ” - Richard Booker, Earl Boysen (Wiley Publishing Inc. 2005).
7.” Handbook of Nanophase and Nanostructured Materials” (in four volumes) Eds: Z.L. Wang, Y. Liu, Z. Zhan Kluwer Academic/Plenum Publishers, 2003.

Elective –II B

VPPH4E22: ADVANCED CONDENSED MATTER PHYSICS

1. Elementary Excitations in Solids

Interacting electron gas- Hatree Fock approximation; Plasmons and electron plasmon interactions; Linhard equation for dielectric constant of electron gas; Electron Hole interactions-excitons; Block and Wannier representations, Frenkel excitons, Ion-ion interactions,-classical equations of motion-Energy in lattice vibrations;Phonon dispersion relations-density of states Spin-spin interactions-magnons. (16**hours)**

Text: Introduction to solid state theory O Madlung Springer Ny1978

2. Alloying phenomenon:

Physics of alloy formation-Phase diagrams and alloy formation-Ternary groups and quaternary groups- band structure calculation of alloys superstructures-quantum well structures- super lattices **(14 hours)**

Text: Semiconductor physics and Devices: S S Islam Oxford

3. **Defects in solids and strength of materials:**

Diffusion in solids, Vacancies, dislocations and mechanical strengths, ionic conductivity etching, photo graphic processes, radiation damage in solids, Fracture, Ductile and brittle fractures, Fracture mechanics, Fatigue, Crack initiation and propagation, Creep, Generalized creep behaviour, Stress and temperature effects **(12 hours)**

Text: Elementary solid state physics, Ali Omar; Pearson and Mechanical properties of matter: AH Cortell, Wiley NY.

4. Nano scale science and technology

Nano materials and Quantum mechanics- quantum dots-Three dimensional Systems(bulk materials)- two dimensional systems(films)-one dimensional systems(quantum wires)-Zero dimensional systems(quantum dots)- Energy levels of quantum dots- nano wires and nano tubessynthesis and applications. **.** **(16 hours)**

Text: Nano technology- Principles and fundamentals: Ed G nter ũ Schmid, Wiley

5. Thin Film Technology and Applications

Thin film Growth process- Nucleation & film growth- Semiconducting thin films-Vapour deposition techniques- Solution deposition techniques- Optoelectronic applications of thin films- Micro electronic applications, Enough exercises. **.** **(14 hours)**

Texts: Thin film devises and applications: Chopra & I Kaur, Plenum Press

Thin Film Fundamentals: A Goswami New Age Publishers

Text and Reference books:

1. Solid State Physics: Structure and Properties of Materials by A. M. Wahab (Narosa Publishing House, India) 2nd Edition 2005
2. Elements of Solid State Physics (second Edition) by J. P. Srivatsava (Printice Hall of India) 2001
3. Introductory Solid State physics by H. P. Myers (Taylor & Francis Ltd, London) 2nd Edition 1998
4. Solid State Physics by Ashcroft & Mermin 1st edition 2003
5. Solid State Physics by C. M. Kachhava (Tata McGraw-Hill) 1st Edition 1996
6. Solid State Physics by Kittle (Wiley, 7th Edition) 2004

ELECTIVE II-C
VPPH4E23: PHYSICS OF SEMICONDUCTORS

1. Band structural aspects :

Effects of temperature and electric field on band structure, Frank-Keldysh effect, Localized states of impurities : theoretical models and experimental probes (Capacitive and spectroscopic techniques), optical properties : allowed and forbidden, and phonon assisted transitions and their spectral shapes, Burstein Moss effect, excitons : free and bound excitons. **(14 hours)**

2. Statistical thermodynamics of carriers :

Fermi level in intrinsic and doped materials, Non stoichiometric semiconductors, role of structural defects, Heavy doping and degeneracy, electrical conductivity, Hall effect – two band model, mobility of carriers, Mechanisms of scattering, measurements of mobility, recombination process, Boltzmann equation for electron transport, equilibrium and non equilibrium processes, effective mass and its measurement, Thermoelectric power, magneto resistivity. **(18 hours)**

3. Metal-semiconductor contacts :

Schottky barrier, P-N junctions, theory of carrier transport in p-n junctions, characteristics of practical junctions and deviations from ideality, capacitance effects, space charge and diffusion capacitance, impurity profiling through capacitance measurements, tunnel diode and applications **(14hours)**

4. Photoconductivity :

Role of traps and recombination, photo voltaic devices for solar cells and radiation detection, luminescence, light emitting diodes and laser action in p-n junction diodes **(12 hours)**

5. Surface states :

Band bending and effect on bulk properties, Thin film structures, low dimensional semiconductors, Quantum wells, multiple quantum well structures, quantum dot structures, methods of preparation, special characteristics and devices based on quantum wells, Quantum Hall effect, high electron mobility transistor , Enough exercises**.** **(14 hours)**

References :

1. R.A Smith – Semiconductors, Academic Publishers, Calcutta (1989)
2. A.B. Lev – Semiconductors and electron devices, Prentice Hall (1987)
3. M. Shur – Physics of Semiconductor devices, Prentice Hall (1990)
4. S.M. Sze – Physics of Semiconductor devices, Wiley Eastern (1991)
5. W. Schockley – Electrons and Holes in semiconductors, D. Van Nostrand (1950)
6. W.C. Dunlop – An introduction to semiconductors, Wiley (1957

ELECTIVE –II D
VPPH4E24: LASERS AND FIBRE OPTICS

1. Basic Laser Theory And Optical Resonators:

Einstein coefficients , Evaluation of transition rates, Line broadening mechanisms, Laser rate equations for three level system, Cavity Modes, Q of cavity, Q Switching, Mode locking , Confocal Resonator, Analysis of optical resonators using geometrical optics. **(16hours)**

2. Types Of Lasers And Applications:

Ruby laser, Helium-Neon laser, Four level solid state lasers, CO2 lasers Dye lasers, Semiconductor lasers, Spatial frequency filtering and holography, Laser induced fusion, Second Harmonic Generation.

(12hours)

3. Optical Fibers:

Introduction, What are optical fibers, Importance, propagation of light in optical fibers, Basic structure, Acceptance angle, Numerical aperture, Stepped index monomode fibers, disadvantages, Graded index monomode fibers, Optical fibers as cylindrical waveguides, Scalar wave equation and the modes of a fiber, Modal analysis for a step index fiber, Single mode fibers. **(20 hours)**

4. Fiber Losses:

Attenuation in optical fibers, Absorption losses, Leaky modes, Radiation induced losses, Inherent defect losses, Inverse square losses, Core and cladding losses. **(10hours)**

5. Measurement On Fibers:

Measurement of numerical aperture and its related terms, measurement of fiber attenuation, Insertion loss method and by optical time domain reflectometer, Measurement of refractive index by reflection method and transmitted near field method, Enough exercises. **(14 hours)**

Books:

1. K.Thyagarajan and Ajoy. K. Ghatak, Lasers : Theory and Application, Macmillan
2. Ajoy Ghatak and K. Thyagarajan, Optical Electronics, Foundation Books (Cambridge University)

Reference Books:

1. William T. Silfast, Laser Fundamentals
2. Subirkumar Sarkar, Optical Fiber and Fiber Optic Communication Systems, S. Chand & Co.
3. Ajoy Ghatak and K.Thayagarajan, Introduction to Fiber Optics, Cambridge.
4. John. M.Senior, Optical Fiber Communications: Principles and Practice

ELECTIVE –III A
VPPH4E31: MODERN OPTICS (4C)

1. Light Propagation and Vectorial Nature:

Electromagnetic wave propagation, Harmonic waves, phase velocity, group velocity, Energy flow Poynting vector. Different polarizations – Matrix representations – Jone's calculus. Ray vectors and ray matrices, Gaussian beams in homogeneous media, ABCD law. **(12 hours)**

Text: (G.R. Fowles, Introduction to Modern Optics, Chapters 1 and 2)

2. Coherence:

Principle of superposition – Theory of partial coherence and visibility of fringes - coherence time and coherence length – Physical origin of line width. Spatial coherence, Hanburry-Brown-Twiss experiment. Basic idea of Fourier Transform Spectroscopy. **(12 hours)**

Text:(G.R. Fowles, Introduction to Modern Optics, Chapter 3)

3. Interference with multiple beams:

Interference with multiple beams – Fabry-Perot interferometer –Resolving power, applications. Theory of multilayer films. **(10 hours)**

Text:(G.R. Fowles, Introduction to Modern Optics, Chapter 4)

4. Diffraction:

Kirchoff's theorem, Fresnel-Kirchoff formula, Babinet's principle, Fresnel and Fraunhoffer diffraction, Fraunhoffer diffraction patterns of single slit, double slit and circular aperture, theory of diffraction grating. Fresnel diffraction pattern – zone plate, Rectangular aperture, Fresnel integrals, Cornu spiral. Applications of Fourier transforms to diffraction. Aperture function, Apodization, Spatial filtering, phase contrast and phase gratings, wave form reconstruction by diffraction holography. **(18 hours)**

Text:(G.R. Fowles, Introduction to Modern Optics, Chapter 5)

5. Optics of Solids:

Microscopic fields and Maxwell's equations. Propagation of light in isotropic dielectric media. Dispersion-Sellmier's formula. Propagation of light in anisotropic media – double refraction, phase velocity surface, polarizing prisms. Optical activity, Faraday rotation in solids, Kerr effect and Pockel's effect (basic ideas only). Elements of nonlinear optics, Physical origin of nonlinearity. Second harmonic generation. Phase matching conditions. Applications of second harmonic generation, Enough exercises. **(20 hours)**

Text:(G.R. Fowles, Introduction to Modern Optics, Chapter 6)

Text Books:
1. G.R. Fowles, Introduction to Modern Optics (Dover Publishers) second edition ISBN: 0486659577
2. A. Yariv, Optical Electronics (1985)

References:
1. S.G. Lupson, H.L. Upaon and D.S. Tannhauser, Optical Physics (Cambridge University Press)
2. A.N. Matvev, Optics (MIR Publishers)
3. Hecht, Optics (Addison Wealey)
4. Ajov-Ghatak, Optics (Tata Mc Graw Hill)

ELECTIVE –III B
VPPH4E32: ASTROPHYSICS

1. Radiative Process:

Theory of Black Body Radiation-Photoelectric Effect-Pressure of Radiation -Absorption and Emission spectra - Doppler Effect - Zeeman Effect- Bremsstrahlung - Synchrotron Radiation - Scattering of Radiation - Compton Effect - and Inverse Compton effect **(10 Hours)**

Text : Baidyanath Basu, Chapter 2

2. Variable stars:

Classification of Variable stars – Cepheid variables – RV Tauri variables - Mira variables – Red Irregular and Semi-regular variables – Beta Canis Majoris Variables–U Geminorum and Flare stars– Theory of Variable stars. **(10 hours)**

Text : Baidyanath Basu, Chapter. 8

3. Galaxies:

The Milkyway galaxy - Kinematics of the Milkyway – Morphology – Galactic Centre – Morphological classification of galaxies – Effects of environment – Galaxy luminosity function – The local group – Surface photometry of galaxies - ellipticals and disk galaxies – Globular cluster systems – Abnormal galaxies-Active galactic nuclei. **(22Hours)**

Text : Binney & Merrifield, Chapter.4

4. General Relativity:

General Considerations - Connection Between Gravity and Geometry - Metric Tensor and Gravity - Particle Trajectories in Gravitational field - Physics in curved space-time – Curvature - Properties of Energy and momentum Tensor - Scwarzchild Metric - Gravitational Collapse and BlackHoles – Gravitational Waves **(18 Hours)**

Text : Padmanabhan, Vol 2, Chapter.11

5. Cosmology:

Cosmological Principle - Cosmic Standard Coordinates - Equivalent Coordinates – Robertson-Walker Metric - The Red Shift - Measures of Distance - RedShift Versus Distance Relation - Steady State Cosmology **(12 Hours)**

Text : Narlikar, Chapter.3

Books Suggested:
1. Gravitation & Cosmology-Steven Weinberg- John Wiley (1972) ISBN: 0-471-92567-5
2. Theoretical Astro Physics Vol 1 and 2- T. Padmanabhan- Cambridge University Press (2000) ISBN: 0-521-56240-6, 0-521-56241-4
3. Quasars and Active Galactic Nuclei- Ajit K Kembhavi and Jayat V Narlikar-Cambridge University Press (1999) ISBN:0-521-47477-9
4. The Physical Universe, An Introduction to Astronomy-F. Shu-Oxford University Press-(1982) ISBN: 0-19-855706-X
5. A Different Approach to Cosmology - Fred Hoyle, Geoffrey, Jayant V Narlikar Cambridge University Press (2000) ISBN:0-521-66223-0
6. An Introduction to AstroPhysics - Baidyanath Basu- Prentice Hall India (1997) ISBN:81-203-1121-3
7. Discovering the Cosmos-R.C. Bless - University Science Books (1996) - ISBN:0- 935702-67-9
8. Text Book of Astronomy and Astrophysics with Elements of Cosmology- V.B. Bhatia-Narosa publications (2001)ISBN:81-7319-339-8
9. Modern Astrophysics - B.W. Carroll & D.A. Ostille - Addison Wesley (1996) ISBN:0-201-54730-9
10. Galactic Astronomy – J. Binney & M. Merrifield, Princeton University Press

11. Galactic Dynamics – J. Binney & S. Tremaine, Princeton University Press
12. An Introduction to Cosmology, Third Edition- J. V. Narlikar, Cambridge University Press (2002)

For further reference:

Astrophysics & Cosmology Video Prof. S. Bharadwaj IIT Kharagpur
http://nptel.iitm.ac.in/courses/115105046/

ELECTIVE –III C

VPPH4E33: CHAOS AND NONLINEAR PHYSICS

1. The Dynamics of Differential Equations :

Integration of linear second order equations by quadrature, The damped oscillator, Integration of nonlinear second order equation, Jacobi elliptic functions, Weierstrass elliptic functions, Periodic structure of elliptic functions, The pendulum equation, Phase portrait of the pendulum, Phase portraits for conservative systems, Linear stability analysis, Linear stability matrix, Classification of fixed points, Examples of fixed point analysis, Limit cycle, Time dependent integrals, Non autonomous systems, The driven oscillator, Remarks on integration of differential equations, Elliptic functions .(Chap 1, Tabor) **(15hours)**

2. Hamiltonian Dynamics :

Lagrangian formulation of mechanics, Lagrangian function and Hamilton's principle, Properties of the Lagrangian and generalized momentum, Hamiltonian formulation of mechanics, Hamilton's equations, Canonical transformations, The preservation of phase volume, The optimal transformation, Generating function, Hamilton Jacobi equation for one degree of freedom, Action angle variable for one degree of freedom, Integrable Hamiltonians, Separable systems, Properties of integrable systems, Examples of integrable systems, Motion on the tori, Fundamental issues, KAM theorem (Chap 2 and sec 3.4, Tabor) **(15 hours)**

3. Chaos in Hamiltonian systems and area preserving mappings :

Surface of section, Surface of section for two degrees of freedom Hamiltonians, The Henon Heiles Hamiltonian, The Toda lattice, Surface of section as a symplectic mapping, Twist maps, Mapping on the plane, Connection between area preserving maps and Hamiltonians, The standard maps, The tangent map, Classification of fixed points, Poincare Birkhoff fixed point theorem, Homoclinic and heteroclinic points, The intersection of H+ and H- whorls and tendrils, Criteria for local chaos, Lyapunov exponents, Power spectra, Criteria for onset of widespread chaos, Method of overlapping resonances, Greene's method, Statistical concepts in strongly chaotic systems, Ergodicity, Mixing, The Baker's transformation and Bernoulli systems, Heirarchies of randomness, Hamiltonian chaos in liquids, Fluid mechanical background, The model system, Experimental results (Sec 4.1 to 4.8, Tabor) **(16 hours)**

4. Dynamics of dissipative systems :

Dissipative systems and turbulence, The Navier Stokes equations, The concept of turbulence-a Hamiltonian degression, Experimental observations on the onset of turbulence, Couette flow, Rayleigh-Benard convection, Landau-Hopf theory, Hopf bifurcation theory, Ruelle-Takens theory, Other scenarios, Fractals, Mathematical model of strange attractors, Lorentz systems, Variations on Lorentz model, The Henon map, Period doubling bifurcations - Period doubling mechanism - Bifurcation diagram – Behaviour beyond 1μ - Other universality classes (Sec. 5.1 to 5.5, Tabor) **(16 hours)**

5. Solitons :

Historical background, Russel's observations, The F U P experiment, Discovery of the soliton, Basic properties of KdV equations, Effects of nonlinearity and dispersion, The traveling wave solution, Enough exercises. (Sec 7.1 and 7.2, Tabor) **(10 hours)**

Text Book:

1. "Chaos and Integrability in Nonlinear Dynamics", M.Tabor (Wiley, New York)

References:

1. "Chaos and Nonlinear Dynamics-An Introduction for Scientists and Engineers", R.Hilborn(Oxford University Press)
2. "Deterministic Chaos -An Introduction", H.G. Schuster (Wiley, New York)
3. "Chaos in Dynamical Systems", E. Ott (Cambridge University Press)
4. "Chaotic Dynamics-An Introduction", G.Baker and J. Gollub (Cambridge University Press)

5. "An Introduction to Chaotic Dynamical Systems", R.L.Devaney(Benjamin-Cummings, CA)
6. "Deterministic Chaos", N.Kumar
7. "Nonlinear dynamics", Laxmana (Springer Verlag, 2001)

Elective III D

VPPH4E34: FOUNDATIONS OF QUANTUM MECHANICS

1. Basic Concepts:

Reflections on the uncertainty principle, Complementarity principle, Information, Theory of quantum beats, The Aharonov – Bohm effect. **(10 hours)**

Texts.; Chapter 3, 4 of George Greenstein & Arthur G. Zajonc

2. The EPR Experiment And Bell's Thorem:

The EPR argument, The BKS theorem, The hidden variable theories, The Bell"s theorem and its proof, Tests of Bell"s inequalities, Alain Aspect"s experiments. **(14 hours)**

Texts.;Chapter 5,6 of George Greenstein & Arthur G. Zajonc & 12 of David J Griffiths.

3. Nonlocality:

Bohm"s nonlocal hidden variable theory, The Mystery of the EPR correlations, Nonlocality and principle of relativity, Quantum Nonlocality. **(12 Hours)**

Texts.;Chapter 6 of George Greenstein & Arthur G. Zajonc

4. Decoherence

Schrödinger"s cat, Super positions and mixtures, Non-observation of quantum behaviour in macro systems, Decoherence, Watching decohrence **(16 Hours)**

Texts.;Chapter 7 of George Greenstein & Arthur G. Zajonc

5. The measurement problem in quantum mechanics:

The measurement problem, The collapse of wave function, The infinite regress, The active nature of measurement in quantum mechanics, Decoherence and measurement problem, Elementary ideas of quantum cryptography and quantum teleportation. **(20 hours)**

Texts.;Chapter 8,9 of George Greenstein & Arthur G. Zajonc

Text Book : The Quantum Challenge: Modern Researches on the foundations of Quantum Mechanics - George Greenstein & Arthur G. Zajonc, Narosa

References:

1.Introduction to Quantum Mechanics: David J Griffiths, Pearson Education
2.Understanding Quantum Mechanics: Roland Omnes, Prentice-Hall, India
3.Quantum Theory and Measurement: J. A. Wheeler and W. H. Zurek, Princeton University Press, Princeton
4.Quantum Mechanics: V.K.Thankappan, Wiley Eastern

For further reference:

Quantum Mechanics and Applications Video Prof. Ajoy Ghatak IIT Delhi
http://nptel.iitm.ac.in/courses/115102023/
Quantum Physics Video Prof. V. Balakrishnan IIT Madras
http://nptel.iitm.ac.in/video.php?subjectId=122106034

Practical for Semesters III & IV

A) VPPH3P03 & VPPH4P03 (MODERN PHYSICS)

*At least 8 experiments are to be done from **Part A** and **2** each from the **optional papers in Part B**. If no practical have been given for the particular optional papers, two more experiments from Part A should be done. One mark is to be deducted from internal marks for each experiment not done by the student if the required total of experiments are not done in the semesters.*

PART A

1. G.M. Counter plateau and statistics of counting - To obtain the plateau, operating voltage and to verify the distribution law satisfied by the radioactive decay

2. Absorption coefficient for beta & gamma rays -To determine the absorption coefficient of the given materials using a G.M.Counter
3. Feather analysis – End point energy - To determine the end point energy of the beta particles from a given source using Feather analysis
4 Conductivity, Reflectivity, sheet resistance and refractive index of thin films
5. Hall effect in semiconductors-To determine the carrier concentration in the given specimen of semiconducting material
6. Absorption spectrum of KMnO4 and Iodine. To determine the wavelength of the absorption bands of KMnO4 and to determine the dissociation energy of iodine molecule from its absorption spectrum.
7. Ultrasonic interferometer. To determine the velocity and compressibility of sound in liquids.
8. Band gap energy of Ge by four probe method.-To study bulk resistance and to determine band gap energy.
9. Thomson's e/m measurement.-To determine charge to mass ratio of the electron by Thomson"s method.
10. Determination of Band gap energy of Ge and Si using diodes.
11. Millikan's oil drop experiment .To measure the charge on the electron
12. Zener voltage characteristic at low and ambient temperatures – To study the variation of the Zener voltage of the given Zener diode with temperature
13. Determination of dielectric constant of materials / non-polar liquids
14.Silicon diode as a temperature sensor.
15. LDR and photodiode characteristics
16. Solar cell -spectral response and I-V characteristics

Part B

II. MATERIAL SCIENCE / CONDENSED MATTER PHYSICS
1. Curie-Weiss law – (To determine the Curie temperature)
2. Study of colour centres – Thermoluminiscence glow curves
3. Thermoluminiscence spectra of alkali halides
4. Thermo emf of bulk samples (Al/Cu)
5. Strain gauge – Y of a metal beam
6. Variation of dielectric constant with temperature of a ferro electric material (Barium titanate)
7. Ionic conductivity of KCl/NaCl crystals
8.Study of physical properties of crystals (specific heat,t hermal expansion, thermal conductivity, dielectric constant)
9.Study of variation of magnetic properties with composition of a ferrite specimen

III. EXPERIMENTAL TECHNIQUES
1. Rydberg constant – hydrogen spectrum
2. ESR – Lande g factor
3. Vacuum pump – pumping speed
5. Vacuum pump – Effect of connecting pipes
6. Absorption bands of Iodine
7. Vibrational bands of AlO
8. X-ray diffraction – analysis of lattice constants of a cubic/Hexagonal crystal with accuracy
9.Growth of single crystal from solution and the determination of its structural,electrical and optical properties (NaCl,KBr,KCl,NH4Cl etc.)
10.indexing the Bragg reflections in a powder X-ray photograph of a crystal

IV Modern Optics
1. Optical fibre characteristics - To determine the numerical aperture, attenuation and band width of the given optical fibre specimen
2.Polarization of light and verification of Malu"s law.
3.Refractive index measurement of a transparent material by measuring Brewster"s angle

4.Thin films – optical properties (Reflectivity, transmission, attenuation, refractive index)
5. Linear electro-optic effect (Pockels effect) – half wave voltage and variation of intensity with electric field.

B) VPPH3P04& VPPH4 P04: COMPUTATIONAL PHYSICS

*The programs are to be executed in Python. For visualization Pylab/matplotlib may be used. At least **twelve** experiments are to be done, opting any six from **Part A** and another six from **Part B**. The Practical examination is of 6 hours duration.*

Interpolation : To interpolate the value of a function using Lagrange's interpolating polynomial
2. Least square fitting :To obtain the slope and intercept by linear and Non-linear fitting.
3. Evaluation of polynomials. Bessel and Legendre functions: Using the series expansion and recurrence relations.
4. Numerical integration : By using Trapezoidal method and Simpson's method
5. Solution of algebraic and transcendental equations .Newton Raphson method, minimum of a function
6. Solution of algebraic equation by Bisection method
7. Matrix addition, multiplication, trace, transpose and inverse
8. Solution of second order differential equation- Runge Kutta method
9. Monte Carlo method : Determination of the value of π by using random numbers
10. Numerical double integration
11. Solution of parabolic/elliptical partial differential equations
(eg: differential equations for heat and mass transfer in fluids and solids, unsteady behaviour of fluid flow past bodies, Laplace equation etc.,)

Part B

Part B

1. To plot the trajectory of a particle moving in a Coulomb field (Rutherford scattering) and to determine the deflection angle as a function of the impact parameter
2. Generate phase space plots - To plot the momentum v/s position plots for the following systems : (i) a conservative case (simple pendulum) (ii) a dissipative case (damped pendulum)
3. Simulation of the wave function for a particle in a box - To plot the wave function and probability density of a particle in a box; Schrödinger equation to be solved and eigen value must be calculated numerically.
4. Simulation of a two slit photon interference experiment : To plot the light intensity as a function of distance along the screen kept at a distance from the two slit arrangement.
5. Trajectory of motion of (a) projectile without air resistance (b) projectile with air resistance
6. Logistic map function – Solution and bifurcation diagram
7. Experiment with Phoenix/expEYES kit - Time constant of RC circuits by curve fitting. *
8. Experiment with Phoenix/expEYES kit - Fourier analysis of different waveforms captured using the instrument. *
(*If Phoenix is not available, data may be given in tabulated form)
9. Simulation of Keplers‟ orbit and verification of Kepler‟s laws.
10. Simulations of small oscillations in simple molecules:: Diatomic molecule/Triatomic molecule for various lengths(any one case)
11. Simulation of random walk in 1D/2D and determination of mean square distance.
12. Simulation of magnetic field - To plot the axial magnetic field v/s distance due to a current loop carrying current.
13. Simulation of the trajectory of a charged particle in a uniform magnetic field.
14. Simulation of polarisation of electromagnetic waves.
15. Simulation of coupled oscillators - Phase space portraits.

Text Books :

1. Computational Physics -An introduction., R.C.Varma, P.K.Ahluwalia and K.C.Sharma, New Age International Publishers

2. Numpy Reference guide, http://docs.scipy.org/doc/numpy/numpy-ref.pdf (free resources available on net)
3. Matplotlib , http://matplotlib.sf.net/Matplotlib.pdf (and other free resources available on net)
4. Numerical Methods in Engineering and Science, Dr. B S Grewal, Khanna Publishers, New Delhi
5. Numerical Methods, E Balagurusamy, Tata McGraw-Hill
6. Numerical Methods , T Veerarajan, T Ramachandran, Tat MCGraw-Hill
7. Numerical Methods with Programs I BASIC, Fortran & Pascal, S Balachandra Rao, C K Shantha. Universities Press
8. Numerical methods for scientists and engineers, K. Sankara Rao, PHI
9. Introductory methods of numerical analysis, S.S.Shastry , (Prentice Hall of India,1983)
10. Numerical Methods in Engineering with Python by Jaan Kiusalaas

Note: Experiments from Part A can be done with data from physical situations where ever possible

Model Question Paper
VIMALA COLLEGE (AUTONOMOUS), THRISSUR
FIRST SEMESTER M.Sc. DEGREE EXAMINATION
(VCCSS)
Physics
VPPH1C01: CLASSICAL MECHANICS

Time: 3 Hours | Maximum: 36 Weightage

Part A

*Answer **all** questions.*

Each question carries a weightage of 1

1. What do you mean by generalized potential? Give an example.
2. Write down the Lagrangian for Kepler problem and derive Kepler's second law.
3. State the principle of least action and use it to obtain principle of least time.
4. Define Poisson bracket of two variables and discuss its important properties
5. Explain how action angle variables can be used to obtain the frequencies of periodic motion .
6. Explain how action angle variables provides a procedure for quantization of systems.
7. Show that in_nitesimal rotations can be represented as rate of change of a vector.
8. Define Coriolis force. Explain its effect on the ight of a missile in the northern hemisphere.
9. Prove that $[L_i\ L_j\ ] = ijkL_k$.
10. Establish that for a particle executing simple harmonic motion, the trajectory in the phase plane is an ellipse.
11. Explain the term 'limit cycle'.
12. What is a Lyapunov exponent? How is it related to chaos?

(12 x 1 = 12 Weightage)

Part B

*Answer any **two** questions.*

Each question carries a weightage of 6

13. (a) Define scattering cross section. What is differential cross section?
    (b) Derive Rutherford expression for differential scattering cross section.
14. (a) What do you mean by Legendre transformation? Use Legendre transformation to obtain Hamiltons canonical equations of motion.(b) Solve Kepler problem using H-J equation.
15. (a)Obtain Euler equations of motion. Derive the period of precession of earth.
    (b) Explain with example the period doubling route to chaos.
16. (a) Explain the free vibrations of a linear triatomic molecule. Obtain the expressions for normal frequencies and and normal coordinates.

(2 x 6 = 12 Weightage)

Part C

*Answer any **four** questions.*

Each question carries a weightage of 3

17. Consider a pendulum made out of a spring with a mass m on the end. The spring is arranged to lie in a straight line (which we can arrange by, say, wrapping the spring around a rigid massless rod).The equilibrium length of the spring is l. Let the spring have length l +x(t), and let its angle withthe vertical be f (t). Assuming that the motion takes place in a vertical plane, find the equations of motions for x and f (t).
18. Using Lagrange's equation of motion, explain the motion of a projectile.
19. Show that the transformationQ = ln((sinp)=q) and P = qcotp is canonical using Poisson brackets and hence show[H; [P;Q]] = 0
20. For what values of a and b, do the equations Q = q^acosbp, P = q^asinbprepresent a canonical transformation.Find the generating function.
21. Using H.J formalism explain the motion of a freely falling body
22. Obtain the components of the angular veocity along the space set of axes in terms of the Euler angles.

(4 x 3 = 12 Weightage)

Model Question Paper
VIMALA COLLEGE (AUTONOMOUS), THRISSUR
FIRST SEMESTER M.Sc. DEGREE EXAMINATION
(VCCSS-PG)
Physics
VPPH1 C02 - MATHEMATICAL PHYSICS I

Time: 3 Hours Maximum: 36 Weightage

Part A

*Answer **all** questions.*
Each question carries a weightage of 1

1. Show that $r^n\mathbf{r}$ is an irrotational vector for any value of n, but solenoidal when n = -3.
2. Express arc length in general orthogonal curvilinear coordinate system.
3. Resolve circular cylindrical unity vectors into cartesian components.
4. Show that Kronecker delta is a second rank mixed tensor.
5. What is a metric tensor? Determine the metric tensor in spherical polar coordinate system.
6. Show that the trace of a matrix is invariant under similarity transformation.
7. Explain the Schmidt orthogonalisation procedure of constructing an orthonormal set of functions from a non orthogonal set.
8. What a singular point is as applied to a differential equation? Explain different types of singular points.
9. Define Γ function. By direct integration show that $\Gamma(n+1) = \Gamma n$.
10. Prove that $xJ_n'(x) = nJ_n(x) - xJ_{n+1}(x)$.
11. Discuss Hamilton's principle in mechanics as a variational problem.
12. Explain Rayleigh-Ritz variational technique.

(12 x 1 = 12 Weightage)

Part B

*Answer any **two** questions.*
Each question carries a weightage of 6

13. Obtain the expression for gradient and divergence in general curvilinear coordinates. Hence deduce the expression for gradient and divergence in spherical polar coordinates.
14. (a) What are Hermitian and Unitary matrices?
    (b) Show that the eigenvalues of a Hermitian matrix are real and eigenvectors are orthogonal to each other.
15. Write down the Bessel's differential equation and find the most general solution of Bessel's equation.
16. (a) Derive Euler's equation by applying variational principle.
    (b) How can it be generalized for the case of several dependent and several independent variables?

(2 x 6 = 12 Weightage)

Part C

*Answer any **four** questions.*

Each question carries a weightage of 3

17. A rigid body is rotating about a fixed axis with a constant angular velocity ω. Take ω to lie along the z-axis. Express **r** in circular cylindrical coordinates and evaluate **v** = ω x **r**.
18. Diagonalise the matrix $\begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$.
19. Using the method of separation of variables, obtain the solution of Laplace's equation in cylindrical coordinates.
20. Express $\int_0^{\pi/2} \sin^p\theta \cos^q\theta \, d\theta$ in terms of gamma function. Using this result, evaluate $\int_0^1 \frac{dx}{(1-x^n)^{1/n}}$.
21. Derive the orthogonality relation for Legendre polynomials.
22. Show by variational method, the shortest distance between two points in a plane is a straight line. (4 x 3 = 12 Weightage)

Model Question Paper
VIMALA COLLEGE (AUTONOMOUS), THRISSUR
FIRST SEMESTER M.Sc. DEGREE EXAMINATION
(VCCSS-PG)
Physics
VPPH1C03 – ELECTRODYNAMICS AND PLASMA PHYSICS

Time: 3 Hours Maximum: 36 Weightage

Part A

*Answer **all** questions.*
Each question carries a weightage of 1

1. Explain the use phasor in time varying fields.
2. What is meant by retarded potential?
3. Explain Poynting theorem and Poynting vector.
4. Define reflection coefficient and transmission coefficient.
5. How should the thickness of the radome in a radar installation be chosen?
6. What is meant by a dipole radiation?
7. What is meant by dominant mode of a waveguide?
8. What are the three basic types of propagating waves in a uniform waveguide?
9. Explain about the distortion less transmission line
10. Represent Lorentz force law in relativistic notation using field vectors.
11. Explain the criteria for a plasma.
12. What is meant by Debye shielding length?

(12 x 1 = 12 Weightage)

Part B

*Answer any **two** questions.*
Each question carries a weightage of 6

13. Discuss the propagation of electromagnetic waves in a conducting media and bring out the idea of skin effect.
14. Discuss the propagation of TE waves in a rectangular waveguide and obtain an expression for the field components, cut-off frequency and phase velocity.
15. With the help of the potential formalism of relativistic electrodynamics, rewrite Maxwell's electromagnetic equations using 4 vector potentials.
16. Discuss in detail, the plasma oscillations.

(2 x 6 = 12 Weightage)

Part C

*Answer any **four** questions.*

Each question carries a weightage of 3

17. Obtain the momentum of the e.m. wave in terms of the Poynting vector.
18. Deduce the laws of reflection and the Snell's law by considering the incidence of e.m. waves on a plane dielectric boundary.
19. (a) What should be the size of a hollow cubic cavity made of copper (σ_c=5.8 x 10^7 S/m) in order for it to have a dominant resonant frequency of 10 GHz?

    (b) Find the quality factor at that frequency.
20. Obtain the multipole expansion V in powers of 1/r.
21. Obtain the relativistic transformation equations for the field vectors **E** and **B**.
22. Obtain an expression for plasma frequency.

(4 x 3 = 12 Weightage)

Model Question Paper
VIMALA COLLEGE (AUTONOMOUS), THRISSUR
FIRST SEMESTER M.Sc. DEGREE EXAMINATION
(VCCSS-PG)
Physics
VPPH1C04: ELECTRONICS

Time: 3 Hours — Maximum: 36 Weightage

Part A

*Answer **all** question.,*
Each question carries a weightage of 1

1. Draw the low frequency equivalent circuit of OPAMP and explain the significance of virtual ground.
2. Define CMRR .Explain why CMRR is important in the instrumentation amplifier applications
3. Write a short note on Pole zero compensation
4. Explain the operation of an OPAMP analog differentiator. Show the output wave for a square wave input.
5. What is meant by slew rate of an OPAMP? What are the causes for slew rate?
6. Write the differences between static and dynamic RAM and sketch the circuit for static RAM
7. What do you mean by racing in JK flip flop ? How this problem can be solved?
8. Write a short note on micro computer
9. What are ripple counters ? Give its advantages.
10. Explain the various addressing modes in 8085 processor**.**
11. Explain the working of a mod 10 counter
12. Explain the function of ALU and IO/M signals in the 8085 architecture?

(12 x 1 = 12 Weightage)

Part B

*Answer any **two** questions.*
Each question carries a weightage of 6

13. With the help of a diagram explain the construction and working of a low pass first order butter worth filter. Explain how is it converted to a second order low pass butterworth filter.
14. (a)What are the different registers in INTEL 8085 microprocessor? Explain their functions. (b)With a block diagram, explain the architecture of INTEL 8085 microprocessor.
15. Discuss the design, working and circuit analysis of an emitter coupled differential amplifier.

16. (a) Briefly sketch the working of an n-channel JFET. (b) Draw the circuit diagram of common source FET amplifier and explain. (c) Draw the low frequency small signal FET equivalent circuit and obtain expressions for the voltage gain and output resistance.

(2 x 6 = 12 Weightage)

Part C

*Answer any **four** questions.*
Each question carries a weightage of 3

17. A truth table has low outputs for inputs 0000 to 0110 and a high input for 0111,a low output for 1000 to 1001 and don't care states for 1010 to 1111.Using K map find the simplest logic circuit for this truth table.
18. Explain the difference between the peripheral I/O and the memory mapped I/O.
19. Draw the circuit of an opamp connected as a scaling amplifier .Show how this circuit can be modified as a summing amplifier.
20. Design an OPAMP Schmitt trigger circuit with an upper triggering voltage 0.2 V and lower triggering voltage -0.2 V if V_{sat} =10V.
21. If V_{GS} of a FET amplifier changes from -4.3 to -4.2 Volts ,the drain current changes from 1 mA to 1.3 mA. Find the voltage amplification if the load resistance Rd is 10 KΩ.Assume $r_d >> R_d$.
22. Write a program for addition of two 8-bit numbers stored in memory locations FC00 and FC01 (using 8085 microprocessor).

(4 x 3 = 12 Weightage)

Model Question Paper
VIMALA COLLEGE (AUTONOMOUS), THRISSUR
SECOND SEMESTER M.Sc. DEGREE EXAMINATION
(VCCSS-PG)
Physics
VPPH2C05: QUANTUM MECHANICS-I

Time: 3 Hours | Maximum: 36 Weightage

Part A

*Answer **all** questions.*
Each question carries a weightage of 1

1. What is Hilbert space?
2. 2.When do you say two functions are orthonormal
3. Outline Dirac bra and ket notaion
4. Expalin the different postulates in quantum mechanics.
5. What are ladder operators
6. The definition of angular momentum is given by L=r x p is not a general one. Why?
7. What do you understand by spin of an electron
8. Distinguish between fermions and bosons
9. What is meant by time independent perturbation
10. What are partial waves?
11. What is slater determinant?
12. Distinguish between laboratory coordinate system and centre of mass coordinate system

(12 x 1 = 12 Weightage)

Part B

*Answer any **two** questions.*
Each question carries a weightage of 6

13. Discuss the problem of addition of angular momentum in quantum mechanics. Calculate the C-G coefficients for j1=1/2 and j2=1/.
14. Expalin the Born approximation theory for scattering
15. Explain the features of Schrodinger picture and Heisenberg picture.
16. What do you mean by identical particles. Define symmetric and antisymmetric wavefunctions.

(2 x 6 = 12 Weightage)

Part C

Answer any four questions.

Each question carries a weightage of 3

17. Define Hermitian operators. Show that the eigen values of a Hermitian operator are real
18. For a spinless particle moving in a poterntial V show that the time reversal operator T commutes with the Hamiltonian
19. What is probability current density vector. Determine this quanity for a plane wave.
20. Determine the change in the partial phase shift when the field V(r) is varied.
21. Calculate the first order correction in wavefunction and energy of an anharmonic oscillator.
22. Find the ground state energy for a 1-D harmonic oscillator $H = \frac{\hbar^2}{2m}$ $*d^2/dx^2+1/2\ mw^2x^2$ using the trial wave function $=Ae^{-bx2}$

(4 x 3 = 12 Weightage)

Model Question Paper
VIMALA COLLEGE (AUTONOMOUS), THRISSUR
SECOND SEMESTER M.Sc. DEGREE EXAMINATION
(VCCSS-PG)
Physics
VPPH2 C06 - MATHEMATICAL PHYSICS II

Time: 3 Hours | Maximum: 36 Weightage

Part A
*Answer **all** questions.*
Each question carries a weightage of 1

1. Express Cauchy Reimann conditions in polar form.
2. What do you mean by essential and irregular singularities of a complex function? Give examples.
3. State and prove Cauchy's integral theorem.
4. Define classes of a group. Give examples.
5. What are Lie groups?
6. What are the features of a character table?
7. Explain the classes of integral equations.
8. Discuss the Neumann's series solution technique of solving integral equations.
9. Explain the essential conditions to be satisfied for a function to be expanded in a Fourier series.
10. Obtain the Laplace transform of the function $f(t) = \sinh at$.
11. Show that the kernel of the harmonic oscillator problem is a Green's function.
12. Prove the symmetric property of Green's function.

(12 x 1 = 12 Weightage)

Part B
*Answer any **two** questions.*
Each question carries a weightage of 6

13. Derive the Laurent's expansion of a complex function. Obtain the Laurent's series of $f(z) = \frac{1}{(1+z^2)(z+2)}$ when $1 < |z| < 2$.
14. Show that SU(2) and SO(3) groups are homomorphic.
15. Obtain the Fourier series of the periodic function f(x) on the interval [-L, +L]. Hence arrive at the expression for Fourier integral.
16. Obtain the one-dimensional Green's function of Sturm Liouville differential equation. Hence list out the properties of a 3-D Green's function?

(2 x 6 = 12 Weightage)

Part C

*Answer any **four** questions.*

Each question carries a weightage of 3

17. Evaluate by the method of residues the integral $\int_0^{2\pi} \frac{d\theta}{5+4\cos\theta}$.
18. Show that $\{i, -1, -i, 1\}$ forms a group under multiplication.
19. Show that the symmetry transformations of a square constitute a group.
20. Solve the equation $\phi(x) = x + \frac{1}{2}\int_{-1}^{1}(t+x)\,\phi(t)dt$.
21. Prove that $\frac{\pi}{4} = \frac{1}{2} + \frac{1}{1.3} - \frac{1}{3.5} + \frac{1}{5.7} - \frac{1}{7.9} + \cdots\cdots$
22. Find the Green's function for harmonic oscillator as eigen function expansion.

(4 x 3 = 12 Weightage)

Model Question Paper
VIMALA COLLEGE (AUTONOMOUS), THRISSUR
SECOND SEMESTER M.Sc. DEGREE EXAMINATION
(VCCSS-PG)
Physics
VPPH2C07 – STATISTICAL MECHANICS

Time: 3 Hours   Maximum: 36 Weightage

Part A

*Answer **all** questions.*
Each question carries a weightage of 1

1. Explain Gibbs paradox?
2. What is the difference between a micro state and macro state?
3. State the postulate of random a priory phases.
4. Define virial coefficient.
5. Explain about the partition function of a canonical ensemble.
6. Obtain the classical ideal gas equation using virial theorem.
7. What is meant by fugacity?
8. Obtain an expression for the expectation value of a physical quantity in terms of quantum mechanical operators.
9. What is the criterion for classifying particles into bosons and fermions?
10. Deduce an expression for energy of a Fermi gas at absolute zero.
11. What is meant by Pauli paramagnetism?
12. How do the degeneracies of Bose-Einstein and Fermi-Dirac gases differ?

(12 x 1 = 12 Weightage)

Part B

*Answer any **two** questions.*
Each question carries a weightage of 6

13. Discuss the theory of paramagnetism by classically and quantum mechanically.
14. Discuss in detail, the density and energy fluctuations in the canonical ensemble.
15. Discuss the thermodynamic behavior of ideal Fermi gas.
16. Outline the thermodynamics of ideal Bose gas.

(2 x 6 = 12 Weightage)

Part C

*Answer any **four** questions.*

Each question carries a weightage of 3

17. Find C_v of a monoatomic ideal gas using equi-partition theorem
18. Show that in the case of photons, the chemical potential is zero.
19. Show that the entropy of a physical system is solely and completely determined by the probability values of the system being in different dynamical states accessible to it.
20. The Fermi energy for lithium is 4.72eV at absolute zero. Calculate the number of conduction electrons per unit volume in lithium.
21. Using density matrix in canonical ensemble, find the expression for $\langle \sigma_z \rangle$ for an electron in a magnetic field.
22. A cubic meter of atomic hydrogen at STP contains about 2.6 x 10^{25} atoms. Find the number of atoms in their first excited state at 1000K.

(4 x 3 = 12 Weightage)

Model Question Paper
VIMALA COLLEGE (AUTONOMOUS), THRISSUR
SECOND SEMESTER M.Sc. DEGREE EXAMINATION
(VCCSS-PG)
Physics
VPPH2C08: COMPUTATIONAL PHYSICS

Time: 3Hours Maximum: 36 Weightage

Part A

*Answer **all** questions.*
Each question carries a weightage of 1

1. What is a module in Python?
2. List the different operators in python.
3. Explain how 'infite looping' is achieved in python.
4. Discuss savings and restorings array in python?
5. Write the syntax for a function call.
6. Explain with general format plot( ) function and show( ).
7. Explain how to create an array from regular python list.
8. What are relevant functions of file ?
9. What is meant by slicing of a string? Write a line of code to demonstrate slicing. .
10. Explain the principle of least square approximation method for curve fitting.
11. What is the importance of finding solutions of algebraic equations in numerical method.
12. Find the inverse of a function f(x)= 4x + 7.

(12 x 1 = 12 Weightage)

Part B

*Answer any **two** questions.*
Each question carries a weightage of 6

13. Explain the Runge-Kutta methods for the solution of first order differential equations. Develop a Python progamme for it.
14. (a) Explain control structures in Python with suitable examples.
    (b) Elucidate the difference between if….else and if….elif statements. Write a program to find a given number is even or odd
15. Explain the terms 'function' and 'modules'
16. Explain with suitable example, how one dimensional array can be indexing slicing and iterating?

(2 x 6 = 12 Weightage)

Part C

*Answer any **four** questions.*

Each question carries a weightage of 3

17. Find $\sqrt[3]{14}$.
18. Write a program to obtain the numerical solution for the motion of a body falling in a viscous medium.
19. How do we create a list in Python? Generate a list of number of your choice and show how to add another number to the list ,find the total number of elements in the list and replace one number in the list with another number.
21. Suppose the position of a point in two dimensional space is given to us in polar coordinates (r,θ). Write a Python program to ask the user to enter the values r and θ(in degrees) and to convert them to Cartesian coordinates x= rcosθ, y= rsinθ.
22. Write a program in python to solve quadratic equation.

(4 x 3 = 12 Weightage)

Model Question Paper
VIMALA COLLEGE (AUTONOMOUS), THRISSUR
THIRD SEMESTER M.Sc. DEGREE EXAMINATION
(VCCSS-PG)
Physics
VPPH3C09: QUANTUM MECHANICS –II

Time: 3 Hours   Maximum: 36 Weightage

Part A

*Answer **all** questions.*
Each question carries a weightage of 1

1. Derive the first order correction to the energy in the presence of a time independent perturbing potential.
2. Show that the ground state of hydrogen atom has no first order stark effect.
3. Obtain the Klein Gordon equation.
4. Obtain the equation of continuity in the case of Dirac equation.
5. Discuss the criteria for the validity of WKB approximation.
6. What are connection formulae? Why are they necessary in WKB approximation?
7. State and explain Fermi's golden rule for transition to a continuum
8. Explain dipole approximation in perturbation theory.
9. Show that the orbital angular momentum is not conserved in Dirac theory.
10. What is the nonrelativistic limit of Dirac equation? Explain the various terms.
11. Discuss penetration of a potential barrier and write down the equation for Transmission coefficient.
12. Dicuss in brief the case of anharmonic oscillator using non degenerate time independent perturbation theory. (12 x 1 = 12 Weightage)

Part B

*Answer any **two** questions.*
Each question carries a weightage of 6

13. Obtain the classical field equation in terms of Lagrangian density. Obtain the equation in terms of functional derivatives.
14. Using time dependent perturbation theory derive the transition probability under harmonic perturbation and apply it to interaction of atom with electromagnetic field. What are Einstein coefficients? Obtain the relation between the coefficients for spontaneous and induced emission.
15. (i)Explain the variational method of approximation.
    (ii)Use the method to estimate the ground state energy of helium atom
    (iii)Compare the result obtained with that of first- order perturbation theory.
16. (i) Describe the salient features of the WKB method of approximation and obtain the general solution of schrodinger equation in the WKB method.

(ii)Apply the method to study the problem of a one dimensional bound system, and hence derive an equation that corresponds to the Bohr Sommerfeld quantisation rule. (no rigid walls)

(2 x 6 = 12 Weightage)

Part C

*Answer any **four** questions.*

Each question carries a weightage of 3

17. Show that the following matrices form a representation of Dirac's matrices:
$\alpha_x = \begin{pmatrix} \sigma_x & 0 \\ 0 & -\sigma_x \end{pmatrix}$, $\alpha_y = \begin{pmatrix} 0 & I \\ I & 0 \end{pmatrix}$, $\alpha_z = \begin{pmatrix} \sigma_z & 0 \\ 0 & -\sigma_z \end{pmatrix}$, $\beta = \begin{pmatrix} 0 & iI \\ -iI & 0 \end{pmatrix}$
18. Which of the following transitions are electric dipole allowed:
(i) 1s→2s (ii) 1s→2p (iii) 2p→ 3d (iv)3s → 5d
19. Obtain the energy values of harmonic oscillator by the WKB method (no rigid walls-Derivation of the formula not required).
20. Consider an α particle having E = 10 MeV, penetrates through a potential barrier of height 30 MeV. If the emitted transmission probability is 2 x 10^{-3}, evaluate the width of the potential barrier.
21. Use the WKB approximation to estimate the transmission coefficient of a particle of mass m and energy E moving in the following potential barrier.
$V(x) = 0$; $x<0$ $\qquad$ $V(x) = V_0-\lambda x$; $x\geq0$
22. Use WKB method to calculate the energy levels of a spinless paricle of mass m moving in a one dimensional box, with walls at x=0 and at x=L(2 rigid walls)(Derive the formula and use it)

(4 x 3 = 12 Weightage)

Model Question Paper

VIMALA COLLEGE (AUTONOMOUS), THRISSUR

THIRD SEMESTER M.Sc. DEGREE EXAMINATION

(VCCSS-PG)

Physics

VPPH3C10: NUCLEAR AND PARTICLE PHYSICS

Time: 3 Hours　　　　　　　　　　　　　　　　　　　　Maximum: 36 Weightage

Part A

*Answer **all** questions.*

Each question carries a weightage of 1

1. Mention any four characteristics of nuclear force.
2. What is meant by multipole radiation? What is its angular momentum?
3. What are the two possible decay modes of an excited state of nucleus. Give conditions under which each decay mode becomes dominant.
4. Give any two classical tests for the Fermi's theory of beta decay
5. Explain the role of the neutrino in parity violation in beta decay.
6. What are the collective motions assosciated with a nucleus?
7. Give the important characteristics of nuclear fission.
8. What is meant by compound nucleus reaction?
9. State and explain the CPT Theorem
10. Write a short note on quantum chromodynamics.
11. Give Gell Mann - Nishijima Formula and GellMann Okubo Mass Formula
12. Give the quark content of π^+, λ^0, Σ^+, **p**, Ω^-, Δ^+

(12 x 1 = 12 Weightage)

Part B

*Answer any **two** questions.*

Each question carries a weightage of 6

13. Discuss the classification of elementary particles based on spin and interaction. Describe the eight fold way and show how the octet and decuplet of particles can be formed.
14. Discuss the Fermi's theory of β decay .Give the selection rules for allowed and forbidden transitions.
15. Discuss the quantum mechanical treatment of deuteron. How far do they corroborate the features of deuteron and the nuclear force?
16. Discuss the shell model including the effect of spin orbit coupling .Also give any three predictions of shell model

(2 x 6 = 12 Weightage)

Part C

*Answer any **four** questions.*

Each question carries a weightage of 3

17. The Q value of the reaction Pb 206 (d, p) Pb 207 is 4.7 MeV. If the Binding Energy of the deuteron is 2.2 MeV Calculate the B.E of last neutron in MeV.
18. State whether the reactions are possible or not and classify the type of interaction
    - I. $\lambda^0 \longrightarrow \pi^+ + \pi^-$
    - II. $\nu+\pi^0 \longrightarrow \pi+ \pi^-$
    - III. $\pi^+ \longrightarrow \mu++\varepsilon^+ +\varepsilon^-$
    - **IV.** $\Sigma^+ \longrightarrow \pi+\gamma$
19. Giving reasons, obtain the ground state spins and parities of the following nuclei : ^{7}Li, ^{16}O, ^{23}Na, ^{27}Al and ^{58}Ni.
20. A given nucleus decays first by beta decay from its 2+ ground state to the 2- excited state of the daughter nucleus which subsequently emits a gamma ray to reach the 0+ ground state.. Using the appropriate selection rules, identify the type of beta transition (Fermi or G-T) and obtain the type (E or M) and multipolarities of the gamma transitions. Which mode of the gamma decay will be predominant?
21. Determine the maximum energy of β- particle emitted when $^3H_1$decays to$^3He_2$.
    Which produces more energy the fusion of $^3H_1$ and $^3He_2$ or $^2H_1$ and $^4He_2$
    $^3H_1$ =3.01605 amu , $^3He_2$= 3.01603 amu, $^2H_1$= 2.01410 amu and $^4He_2$= 4.02603 amu
22. The nucleus of ^{164} Er has a **2+** first excited rotational state at 91.4keV .Find the next two excited states of the nucleus. Also find the moment of inertia of the nucleus in **h^2/ keV.**

(4 x 3 = 12 Weightage)

Model Question Paper
VIMALA COLLEGE (AUTONOMOUS), THRISSUR
THIRD SEMESTER M.Sc. DEGREE EXAMINATION
(VCCSS-PG)
Physics
VPPH3C11: SOLID STATE PHYSICS

Time: 3 Hours Maximum: 36 Weightage

Part A

*Answer **all** questions.*
Each question carries a weightage of 1

1. Find the reciprocal lattice of af.c.c lattice.
2. What are Brillouin zones?
3. State the differences between Einstein's and Debye's model of specific heat in crystalline solids.
4. Explain Landau theory of ferroelectric phase transitions.
5. Describe Hall effect.
6. What is Bloch function?
7. Describe with suitable diagrams, the seven crystal systems.
8. What are magnons and how do they differ from phonons?
9. State and explain Meissner effect.
10. Explain the concept of BCS ground state
11. .Discuss the spontaneous polarisation of BaTiO3 crystal.
12. Discuss the light dependence of resistance in LDRs. Construct a circuit showing the application of LDR.

(12 x 1 = 12 Weightage)

Part B

*Answer any **two** questions.*
Each question carries a weightage of 6

13. What is meant by Madelung interaction? Discuss the nature of cohesion and obtain the expression for cohesive energy of an ionic crystal.
14. .Discuss the variation of specific heat capacity of a solid with temperature and use Debye's theory to explain it.
15. Derive an expression for the density of energy states in a metal and hence calculate the fermi energy.
16. Discuss D.C and A.C Josephson's effect and explain their importance. Explain SQUID.

(2 x 6 = 12 Weightage)

Part C

*Answer any **four** questions.*

Each question carries a weightage of 3

17. Show that the inter-planar spacing between two adjacent planes of Miller indices (h,k,l) in a cubic lattice of lattice constant a is $d_{hkl} = \frac{a}{\sqrt{h^2+k^2+l^2}}$
18. In a tetragonal lattice a=b=2.5A.U and c=1.8 A.U. Determine the lattice spacing between (111) planes.
19. Diamond (atomic weight of carbon = 12) has Young's modulus of 10^{12}N/m^2 and a density of 3500Kg/m^3. Ignoring crystalline anisotropy and the difference between longitudinal and shear elastic moduli, calculate Debye temperature.
20. The density of silver is 10.5g/cc and its atomic weight is 107.9.Assuming that each silver atom provides one conduction electron, calculate the number of free electrons per cc. Take conductivity of silver as 6.8 x 10^7mhos/m. Calculate the mobility of free electrons.
21. The critical temperature for mercury with isotopic mass 199.5 is 4.185 K. Calculate its critical temperature when the isotopic mass changes to 203.4.
22. Calculate the photon current and carrier transit time for a photoconductor from the following data. Quantum efficiency = 75%, number of photons reaching per second = 1010, mobility = 3000 cm2/V-s, effective electric field = 5 KV/cm, L = 10µm, carrier life time 0.7 ns.

(4 x 3 = 12 Weightage)

Model Question Paper
VIMALA COLLEGE (AUTONOMOUS), THRISSUR
THIRD SEMESTER M.Sc. DEGREE EXAMINATION
(VCCSS-PG)
Physics
VPPH3E11- EXPERIMENTAL TECHNIQUES

Time: 3 Hours Maximum: 36 Weightage

Part A

*Answer **all** questions.*
Each question carries a weightage of 1

1. Explain what happens when a rotary pump is suddenly stopped under vacuum.
2. Explain the principle and working of getter ion pump?
3. Discuss the principle of operation of a pirani gauge.
4. Explain the principle of thin film fabrication by sputtering technique.
5. Explain the principle of measurement of thin film thickness by quartz crystal method.
6. Explain the inversion curve and its usefulness in liquefaction of gases?
7. Describe the properties of two isotopes of helium . explain what is superfluidity.
8. Explain how a super conductor can be used as a thermal switch.
9. Explain tandem principle employed in Tandem Van de Graaff accelearators?
10. How phase stability is attained in a synchrocyclotron.
11. Discuss the principle and applications of XRD technique?
12. Discuss briefly any two methods for synthesis of nanomaterials

(12 x 1 = 12 Weightage)

Part B

*Answer any **two** questions.*
Each question carries a weightage of 6

13. With necessary diagrams describe Hompson/ Linde process and Claude process for liquefaction of air. Compare the methods.
14. Describe the principle of an electrostatic accelerator. With the help of diagram describe the principle and working of a cascade accelerator.
15. Describe with the help of a diagram, the principle and working of a diffusion pump. compare it with the turbo molecular pump.
16. With the help of a diagram describe the four probe method for the thickness measurement of thin films.

(2 x 6 = 12 Weightage)

Part C

*Answer any **four** questions.*

Each question carries a weightage of 3

17. Derive expression for thickness of thin film in terms of refractive index of the material of film and wavelength λ_1 of the k^{th}order and $(k+1)^{th}$ order one at wavelength λ_2 at normal incidence.
18. Protons of energy 0.5 MeV are injected into 50MeV linear accelerator powered by a 200MHz RF supply. Find the approximate length of the first and last drift tubes.
19. A fifteen stage turbomolecular pump with a blade tip velocity of 500m/s has a compression ratio of $7.7X10^8$ for N_2 at 25^0C . What is the compression ratio if the pump is pumping hydrogen.
20. A rotary pump has a compression ratio of 10^5. What is the ultimate vacuum expected from this pump.
21. A quartz crystal monitor indicates a change in frequency of 1600Hz when aluminium film of density 2.7g/ccis deposited on its face. Determine the thickness of the film. If the quartz crystal is 0.2mm thick and the density of quartz is 2.3g/cc, estimate the starting frequency
22. For an electron and a proton moving along circles in a uniform magnetic field B= 10kG determine the orbital periods and radii if the KE of the particle is 10MeV. Also find kinetic energies if the orbital radius is 10cm.

(4 x 3 = 12 Weightage)

Model Question Paper
VIMALA COLLEGE (AUTONOMOUS), THRISSUR
FOURTH SEMESTER M.Sc. DEGREE EXAMINATION
(VCCSS-PG)
Physics
VPPH4 C12- SPECTROSCOPY

Time: 3 Hours Maximum: 36 Weightage

Part A

Answer ***all*** *questions*

Each question carries a weightage of 1

1. The magnetic moment μ of an atom never points in the z direction. Explain.
2. Distinguish between normal and anomalous Zeeman effect.
3. Write a note on the intensity of the lines of rotational spectra
4. Explain the effect of anharmonicity on the vibrational spectra of a diatomic molecule.
5. What is predissociation? How can we account for it?
6. What is Hyper Raman effect?
7. What is Fortrat parabola?
8. Outline the Principle of ESR spectra
9. What is chemical shift . explain with example.
10. Explain singlet and triplet states with examples
11. Discuss the principle behind Mossbauer Spectroscopy
12. Illustrate mutual exclusion principle.

(12 x 1 = 12 Weightage)

Part B

Answer any ***two*** *questions.*

Each question carries a weightage of 6

13. Explain vector atom model. What are the wave numbers associated with vector atom model.
14. Write the instrumentation of IR spectroscopy. Write a note on FTIR spectroscopy.
15. Explain different relaxation processes for nuclei and derive Bloch equation.
16. Discuss in detail the rotational fine structure of electronic transitions

(2 x 6 = 12 Weightage)

Part C

Answer any ***four*** *questions.*

Each question carries a weightage of 3

17. Draw the anomalous Zeeman pattern for D_1 and D_2 lines of sodium and obtain the frequencies

18. A free electron is placed in a magnetic field of 2.6T. calculate the resonant frequency g=2.0027. μ_B= 9.27x10^{-24}
19. Draw the energy levels and spectral lines of a vibrating diatomic rotator.
20. Briefly explain Franc Condon Principle
21. Draw the normal Zeeman Pattern for $^1F_3$ to $^1D_2$ transition.
22. The average line spacing between successive rotational lines of CO molecule is 3.8626 cm^{-2}. Determine the transition which give the most intense line at room temperature.

(4 x 3 = 12 Weightage)

Model Question Paper
VIMALA COLLEGE (AUTONOMOUS), THRISSUR
FOURTH SEMESTER M.Sc. DEGREE EXAMINATION
(VCCSS-PG)
Physics
VPPH4E21 MATERIAL SCIENCE

Time: 3 Hours Maximum: 36 Weightage

Part A

*Answer **all** questions.*
Each question carries a weightage of 1

1. Explain Burgers vector .
2. What are surface imperfections?
3. Explain Dislocation multiplication
4. Why ceramic materials are used as dielectrics?
5. What are the fundamental mechanisms by which atoms move through the crystal? Explain.
6. Define ductile and non ductile fracture
7. Discuss the tensile stress-strain curve and give its applications.
8. Explain the branching in polymers.
9. Discuss the electrical behaviour of ceramics.
10. Distinguish between MEMS and NEMS
11. What is meant by spintronics?
12. .What is fullerene? How is it formed?

(12 x 1 = 12 Weightage)

Part B

*Answer any **two** questions.*
Each question carries a weightage of 6

13. Discuss the thermodynamics of point defects in crystals. Arrive at the expression for the equilibrium concentrations for Frenkel and Schotkey defects.
14. Explain in detail how phase diagrams are classified. Discuss the significance of triple points in a phase diagram.
15. (a) What do you understand by Polymerisation? Explain the different types of polymerization.
(b) Write short notes on thermoplastic and thermosetting resins.
16. Explain the Low dimensional structures—Quantum well, Quantum wire and quantum dots.

(2 x 6 = 12 Weightage)

Part C

*Answer any **four** questions.*
Each question carries a weightage of 3

17. An Aluminium crystal is bent into a radius of curvature of 5 cm. What is the minimum dislocation density in the material, given Burgers vector =3 A^o ?
18. The diffusion co-efficient for Li in Ge at 500 ^oC is of the order of 10^{-10} m^2/s. What is the approximate distance of penetration in one hour.
19. Styrene is polymeriseed to a DOP of 10,000. Calculate its molecular weight.
20. Show that the total elastic energy per unit length Es of the screw dislocation is proportional to Gb^2 where G is the shear modulus and b the Burgers vector.
21. State the lever law and explain how it can be used to find the percentage of each phase present in an alloy.
22. Describe a method of synthesis of carbon nano tube .What is multiwalled carbon nanotube?

(4 x 3 = 12 Weightage)

Model Question Paper
VIMALA COLLEGE (AUTONOMOUS), THRISSUR
FOURTH SEMESTER M.Sc. DEGREE EXAMINATION
(VCCSS-PG)
Physics
VPPH4E31: MODERN OPTICS

Time: 3 Hours   Maximum: 36 Weightage

Part A

*Answer **all** questions.*
Each question carries a weightage of 1

1. What is linear polarisation of an electromagnetic wave?
2. What is partial polarisation? Define degree of polarisation.
3. Distinguish between phase velocity and group velocity.
4. What is the principle of superposition?
5. Define coherence length and coherence time.
6. What is multiple beam interference?
7. How much resolving power can a Fabry Perot interferometer achieve? Compare it with that of a prism.
8. What are complimentary apertures? Hence state Babinet' s theorem.
9. Explain Rayleigh criterion for optical resolution.
10. What is a zone plate? Give its practical application.
11. Explain the phenomenon of double refraction. What are double prisms?
12. What is interaction length?

(12 x 1 = 12 Weightage)

Part B

*Answer any **two** questions.*
Each question carries a weightage of 6

13. Explain how matrix representation of polarization is done using Jones calculus. Illustrate the uses of Jones matrices.
14. Discuss the propagation of electromagnetic waves in anisotropic media.
15. Using the theory of partial coherence, derive expressions for the degree of Partial coherence and fringe visibility.
16. Describe the construction and working of a Fabrey-Perot interferometer. Explain how is it used to measure wavelengths with high precision.

(2 x 6 = 12 Weightage)

Part C

*Answer any **four** questions.*

Each question carries a weightage of 3

17. State Poynting's theorem. Derive an expression for the average Poynting flux.
18. Briefly explain the working of Hanbury-Brown Twiss interferometer.
19. What is resolving power? What are the factors affecting the resolving power? What is the usefulness of multilayer dielectric films?
20. .Prove that in the case of diffraction due to a single slit the angular width of the diffraction pattern varies inversely with the slit width.
21. What is apodization? What is its use? Show the aperture functions of a slit and an apodized slit.
22. What is Kerr Electro-optic effect? Explain how a Kerr cell is used as a Kerr cell light modulator?

(4 x 3 = 12 Weightage)