Master of Science

PHYSICS

PROGRAM STRUCTURE AND SYLLABUS

2019-20 ADMISSION ONWARDS

(UNDER MAHATMA GANDHI UNIVERSITY PGCSS REGULATIONS 2019)

BOARD OF STUDIES IN PHYSICS (PG)

MAHATMA GANDHI UNIVERSITY

2019

MAHATMA GANDHI UNIVERSITY, KOTTAYAM

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CONTENTS

MSc. Degree program (Mahatma Gandhi University regulations PGCSS 2019 from 2019-20 academic year)

1. Aim of the program

MSc. Physics forms the final formal training of Physics and hence the program aims at providing an in depth knowledge of Physics to the student. After the successful completion of the program , a student should be capable of pursuing research in theoretical/ experimental physics or related areas.The student is expected to acquire a thorough understanding of the fundamentals ofPhysics so as to select an academic career in secondary or tertiary level.The program also aims at enhancing the employability of the student. Rigorous training requires phased teaching. With this intention credit and semester system is followed in this program.An M.Sc student should be capable of doing research at least in the preliminary way.To accomplish this ,research oriented project is made part of this curriculum

2 Eligibility for admissions

Bachelor's degree in physics with an aggregate minimum of 50%marks

3 Medium of instruction and assessment

English

4 Faculty under which the degree is awarded

Science

5 Specialization offered if any

(1)Electronics,(2) Material science,(3) Informatics (4) Theoretical physics

6 Note on compliance with the UGC minimum standards for the conduct and award of postgraduate degrees.

MSc Physics is a two year program in which credit and semester system is followed . An M.Sc student should be capable of doing research at least in the preliminary way. To accomplish this,research oriented project is made part of this curriculum .There are 18 weeks in a semester and in each week there are15 lecture hours and 10 laboratory hours. In each semester there are 270 lecture hours and 180 practical hours Thus the total calendar hours in each semester is 450 which is in compliance with the minimum 390 hours stipulated by the UGC.

PREFACE

The P.G. syllabus in Physics is restructured to suit the credit and semester system to be followed by the affiliated colleges under Mahatma Gandhi (M.G.) University, Kottayam, from the academic year 2019- 2020. Now as the continuation of the credit and semester system being followed in the U.G. courses in the university, the present restructuring of P.G. curriculum becomes inevitable.

In the restructuring of the P.G. syllabus, the Board of Studies has taken into account the emerging trends in the various fields of theoretical and experimental physics. The thrust was given to inculcate in students the spirit of hard work and research aptitude to pursue higher education in the nationally /internationally reputed institutions and laboratories. Wide discussion in this matter was carried out among the physics teaching community of the M.G. University and experts from various other universities and institutions across the country. A three day workshop was conducted on January17,18 and 19, 2019 with representatives from P.G. departments of all affiliated colleges of the university

In order to accommodate various front running fields in physics, and for the students to have option to select the courses of their interest, the Board has decided to present four Elective Bunch with three courses each in the P.G. syllabus. The elective courses are accommodated in the third and fourth semesters of the P G program. The syllabus of physics practicals is also revised keeping in view of the advances in various fields of physics and technology. Each semester will have one practical each with two practical exams at the end of even semesters. This syllabus is to be followed by all the affiliated colleges under M.G. University. The syllabi of a parallel M.Sc. program run by one college is also restructured to accommodate in the Credit and Semester System.

Chapter - I is dedicated to the General Scheme of the Syllabi. The general M.Sc. program in physics with the course structures in all four semesters are also given in this chapter. Grading and Evaluation is discussed in Chapter - II. The pattern of question papers of theory and practical and the respective internal and external evaluation schemes are discussed here. In Chapter - III, the syllabi of the general M.Sc Physics program is given. Chapter - IV is dedicated for the the syllabi of parallel M.Sc. programs.

CHAPTER-I

1. GENERAL SCHEME OF THE SYLLABI

1.1 Theory Courses: There are fifteen theory courses in all four semesters in the M.Sc. Program. Distribution of theory courses is as follows. There are twelve core courses common to all students. Semester I and Semester II will have **four** core courses each and Semester III will have **three** core courses and Semester IV will have **one** core course. **One** elective course is in semester III and **two** elective courses are in semester IV. There are four Elective Bunch offered in this syllabus. An Elective Bunch has three theory courses. A college can choose one Elective Bunch in one academic year.

1.2 Practicals: All four semesters will have a course on laboratory practicals. The laboratory practicals of Semesters I, II and IV are common courses. The Semester III laboratory practical course will change, subject to the Elective Bunch opted by the college. A minimum of 12 experiments should be done and recorded in each semester. The practical examinations will be conducted at the respective examination centers by two external examiners appointed by the university at the end of even semesters only. The first and second semester examinations of laboratory practical courses will be conducted at the end of Semester II while the third and fourth semester practical examinations will be conducted at the end of Semester IV.

1.3 Project: The project of the PG program should be relevant and innovative in nature. The type of project can be decided by the student and the guide (a faculty of the department or other department/college/university/institution). The project work should be taken up seriously by the student and the guide. The project should be aimed to motivate the inquisitive and research aptitude of the students. The students may be encouraged to present the results of the project in seminars/symposia. The conduct of the project may be started at the beginning of Semester III, with its evaluation scheduled at the end of Semester IV along with the practical examination as being practiced in the present syllabus. The project is evaluated by the external examiners. The project guide or a faculty member deputed by the head of the department may be present at the time of project evaluation. This is to facilitate the proper assessment of the project.

1.4 Viva Voce: A viva voce examination will be conducted by the two external examiners at the time of evaluation of the project. The components of viva consists of subject of special interest, fundamental physics, topics covering all semesters and awareness of current and advanced topics.

1.5 Course Code: The 12 core courses in the program are codedaccording to the following criteria. The first two letters of the code indicates the name of program, ie. PH stands for Physics. The next two digits indicate the stream. The next two digits indicate the semester and the last two digits run for the core courses (Refer Table 1.1)The elective courses are coded as follows. In PH800403, 80 stands for the Elective Bunch A (ELECTRONICS),04 stands for fourth semester and the digit0 3 stands for the 3rd course of the Elective Bunch. (Refer Table 1.2)

Laboratory Practical courses are similarly coded. (Eg: PH0101P means I Semester, General Physics Lab).PH800302 is the Advanced Practicals in Electronics, PH810302 is the Advanced Practicals in Material Science. etc.

1.6 Course Structure of M.Sc. Physics Program:

This is the PG program followed by all affiliated colleges under Mahatma Gandhi University. Apart from this, one affiliated college has a PG progamme in Physics with different course structure. This is discussed in Chapter IV. The detailed structure of the Core courses common to all students of the program is given in Table 1.1

Table 1.1: Structure of MSc Physics under PG-CSS 2019

Semester	Course Code	Name of the courses	No of hrs / week	Credits
I	PH010101	Mathematical methods in Physics – I	3	3
	PH010102	Classical Mechanics	4	4
	PH010103	Electrodynamics	4	4
	PH010104	Electronics	4	4
	PH010105	General Physics Practicals	10	4
		Total for Semester 1	**25**	**19**
II	PH010201	Mathematical methods in Physics – II	4	4
	PH010202	Quantum Mechanics – I	3	4
	PH010203	Statistical Mechanics	4	4
	PH010204	Condensed Matter Physics	4	4
	PH010205	Electronics Practicals	10	4
		Total for Semester 2	**25**	**20**
III	PH010301	Quantum Mechanics – II	4	4
	PH010302	Computational Physics	4	4
	PH010303	Atomic and Molecular Physics	4	4
		Elective – 1	3	3
		Advanced Elective Practicals	10	5
		Total for Semester 3	**25**	**20**
IV	PH010401	Nuclear and Particle Physics	5	4
		Elective – 2	5	3
		Elective – 3	5	3
	PH010402	Computational Physics Practicals	10	4
	PH010403	Project	-	5
	PH010404	Comprehensive viva voce	-	2
		Total for Semester 4	**25**	**21**
		Grand Total		**80**

1.7 The Elective Bunches:

There are four Electives Bunches offered in this PGCSS Program. Each elective consists of a bunch of three theory courses and one laboratory course. The first theory course and the laboratory course of a bunch are placed in the Semester III, while the second and third are in Semester IV.An institution can select only one Elective Bunch in an academic year. The course structure of the Electives Bunches is given in Table 1.2

The Electives Bunches are named,

(i) Bunch A : Electronics
(ii) Bunch B : Material Science
(iii) Bunch C : Informatics
(iv) Bunch D : Theoretical Physics.

Table 1.2: The Elective Bunch

Bunch A: Electronics Specialization : Course code 80

Semester	Course Code	Course Title	No. of hrs / week	Credits
3	PH800301	Digital Signal Processing	3	3
4	PH800402	Micro Electronics and Semi Conductor Devices	5	3
4	PH800403	Communication Systems	5	3
3	PH800302	Advanced Practicals in Electronics	10	5

Bunch B: Materials Science Specialization :Course code 81

Semester	Course Code	Course Title	No. of hrs / week	Credits
3	PH810301	Solid State Physics for Materials	3	3
4	PH810402	Science of Advanced Materials	5	3
4	PH810403	Nanostructures and Materials Characterisation	5	3
3	PH810302	Advanced Practicals in Materials Science	10	5

Bunch C: Informatics Specialization:Course code 82

Semester	Course Code	Course Title	No. of hrs / week	Credits
3	PH820301	Programming in JAVA and HTML	3	3
4	PH820402	Data Communication and Computer Networks	5	3
4	PH820403	Computer applications in Physics	5	3
3	PH820302	Practicals in Informatics	10	5

Bunch D: Theoretical Physics:Course code 83

Semester	Course Code	Course Title	No. of hrs / week	Credits
3	PH830301	General Relativity and Applications	3	3
4	PH830402	Nonlinear Dynamics	5	3
4	PH830403	Quantum Field Theory	5	3
3	PH830302	Special Computational Practicals	10	5

1.8 Distribution of Credit: The total credit for the program is fixed at 80. The distribution of credit points in each semester and allocation of the number of credit for theory courses, practicals, project and viva is shown in Table 1.1 and Table 1.2.

CHAPTER - II

2. GRADING AND EVALUATION

2.1 Examinations

The evaluation of each course shall contain two parts such as Internal or In-Semester Assessment (IA) and External or End-Semester Assessment (EA). The ratio between internal and external examinations shall be 1:3.

Evaluation(Both internal and external)to be done by the teacher is based on a six point scale as shown in the table below

Grade	**Grade Points**
A+	**5**
A	**4**
B	**3**
C	**2**
D	**1**
E	**0**

Direct Grading System based on a 7 – point scale is used to evaluate the performance of students in both External and Internal Examinations .

For all courses (theory & practical) / semester/overall program letter grades and **GPA/SGPA/CGPA** are given in the following table 2.1:

Range	**Grade**	**Indicator**
4.50 to 5.00	**A+**	**Outstanding**
4.00 to 4.49	**A**	**Excellent**
3.50 to 3.99	**B+**	**Very good**
3.00 to 3.49	**B**	**Good(Average)**
2.50 to 2.99	**C+**	**Fair**
2.00 to 2.49	**C**	**Marginal**
up to 1.99	**D**	**Deficient(Fail)**

2.2 Internal or In-Semester Assessment (IA)

Internal evaluation is to be done by continuous assessments of the following components. The components of the internal evaluation for theory and practicals and their weights are as in the Table 2.2and Table2.3. . The components of the internal evaluation for project and comprehensive viva- voce and their weights are as in the Table 2.4and Table2.5The internal assessment should be fair and transparent. The evaluation of the components should be published and acknowledged by students. All documents of internal assessments are to be kept in the institution for 2 years and shall be made available for verification by the university. The responsibility of evaluating the internal assessment is vested on the teacher(s) who teach the course. The two test papers should be in the same model as the end semester examination question paper, the model of which is discussed in the Section 2.3. The duration and the number of questions in the paper may be adjusted judiciously by the college for the sake of convenience.

There shall be no separate minimum grade point for internal evaluation of Theory, Practical, Project, and Comprehensive viva-voce. No separate minimum is required for Internal evaluation for a pass, but a minimum **C** grade is required for a pass in an external evaluation. However, a minimum **C grade** is required for pass in a course.

2.2.1Attendance ,Assignment and seminar

Attendance is not a component for the internal evaluation.But students with attendance less than 75% in a course are not eligible to attend external examination of that course.. The performance of students in the seminar and assignment should also be documented.

2.2.2 Project Evaluation

The internal evaluation of the project is done by the supervising guide of the department or the member of the faculty decided by the head of the department. The project work may be started at the beginning of the Semester III. The supervising guide should keenly and sincerely observe the performance of the student during the course of project work. The supervising guide is expected to inculcate in student(s), the research aptitude and aspiration to learn and aim high in the realm of research and development. A maximum of three students may be allowed to perform one project work if the volume of the work demands it.Project evaluation begins with (i) the selection of problem, (ii) literature survey, (iii) work plan, (iv) experimental / theoretical setup/data collection, (v) characterization techniques/computation/analysis (vi) use of modern software for data analysis/experiments (Origin, LABView, MATLAB, ...etc) and (vi) preparation of dissertation. The project internal grades are to be submitted at the end of Semester IV. The internal evaluation is to done as per the following general criteria given in Table 2.4

The internal evaluation of comprehensive viva-voce is to done as per the following general criteria given in Table 2.5

Table 2.2 Theory-Internal

For Theory(Internal)- Components and Weightage

	Components	**Weightage**
i.	Assignment	1
ii	Seminar	2
iv	Best Two Test papers	1 each (2)
	Total	**5**

Table 2.3 Practical-Internal

For Practical(Internal)- Components and Weightage

	Components	**Weightage**
	Written/Lab test	2
	Lab involvement and Record	1
	Viva	2
	Total	**5**

Table 2.4 Project- Internal

For Project(Internal)- Components and Weightage

	Components	**Weightage**
	Relevance of the topic and analysis	2
	Project content and presentation	1
	Project viva	2
	Total	**5**

Table 2.5 Comprehensive Viva- Internal

Comprehensive viva (Internal)- Components and Weightage

Components	**Weightage**
Subject of special interest, fundamental physics, topics covering all semesters and awareness of current and advanced topics.	5
Total	**5**

2.2.3 General Instructions

i. The assignments/ seminars / test papers are to be conducted at regular intervals.. These should be marked and promptly returned to the students.

ii. One teacher appointed by the Head of the Department will act as a coordinator for consolidating grade sheet for internal evaluation in the department in the format supplied by the University. The consolidated grade sheets are to be published in the department notice board, one week before the closing of the classes for end semester examinations. The grade sheet should be signed by the coordinator and counter signed by the Head of the Department and the college Principal.

iii. The consolidated grades in specific format supplied by the university areto be kept in the college for future references. The consolidated grades ineach course should be uploaded to the University Portal at the end of eachsemester as directed by the University.

iv. A candidate who fails to register for the examination in a particular semester is not eligible to continue in the subsequent semester.

v. Grievance Redress Mechanism for Internal evaluation: There will be provision for grievance redress at four levels, viz,

   a. at the level of teacher concerned,
   b. at the level of departmental committee consisting of Head of the Department, Coordinator and teacher concerned,
   c. at the level of college committee consisting of the Principal, Head of the Department and one member of the college council, nominated by the principal each year,
   d. at the university level committee consisting of Pro-Vice Chancellor /Dean of the Faculty, the controller of examinations and the Convener of the Standing Committee on Academic Affairs of the Syndicate.

College level complaints should be filed within one week of the publication of results and decisions taken within the next two weeks. University level complaints will be made within the time stipulated by the University and decisions will be taken within one month of the last date fixed for filing complaints.

2.3 External Evaluation (EA)

The external examination of all semesters shall be conducted by the university on the close of each semester. There will be no supplementary examinations.

2.3.1 Question Paper Pattern for Theory Courses.

All the theory question papers are of three hour duration. All question papers will have three parts. The question shall be prepared in such a way that the answers can be awarded **A+,A,B,C,D,E.**

Part A: Questions from this part are very short answer type. Eight questions have to be answered from among ten questions. Each question will have weight one and the Part A will have a total weight of eight. A minimum of two questions must be asked from each unit of the course.

Part B: Part B consists of problem solving and short essay type questions from the course concerned. Six questions out of eight given have to be answered. Each question has a weight two making the Part B to have total weight twelve. Minimum of three problems should be asked in Part B ..

Part C: Part C will have four questions. One question from each unit must be asked . Each question will have a weight five making the total weight ten in Part C.
Maximum weight for external evaluation is **30.**Therefore Maximum Weighted Grade Point (WGP) is **150**

Different types of questions shall be given different weights to quantify their range as shown below:

	Type of Questions	**Weight**	**Number of questions to be answered**
Part A	Short Answer type questions	1	8 out of 10
Part B	Short essay/ problem solving type questions	2	6 out of 8
Part C.	Long Essay type questions	5	2 out of 4

2.3.2 Practical, Project and Viva Voce Examinations

First and second semester practical examinations are conducted at the end of Semester II and third and fourth semester practical examinations are conducted at the end of Semester IV. The practical examinations are conducted immediately after the second and fourth semester theory examinations respectively. There will be two practical examination boards even' year to conduct these practical exams. All practical examinations will be of five hours duration. Two examiners from the panel of examiners of the university will be deputed by the board chairman to each of the examination centers for the fair and transparent conduct of examinations. Practical examination is conducted in batches having a maximum of eight students. The board enjoys the right to decide on the components of practical and the respective weights.

Project Evaluation: The project is evaluated by the two external examiners deputed from the board of practical examination. The dissertation of the project is examined along with the oral presentation of the project by the candidate. The examiners should ascertain that the project and report are genuine. Innovative projects or the results/findings of the project presented in national seminars may be given maximum advantage. The supervising guide or the faculty appointed by the head of the department may be allowed to be present at the time of project evaluation. This is only to facilitate proper evaluation of the project. The different weight for assessment of different components is shown in Table 2.5.

Table 2.5 Project- External

For Project(External) Components and Weightage

Components	Weightage
Relevance of the topic and analysis	3
Project content and presentation	7
Project viva	5
Total	**15**

Comprehensive Viva- Voce Examination: Viva voce examination is conducted only by the two external examiners of the board of practical examinations. The viva voce examination is given a credit two. The examination should be conducted in the following format shown in Table 2.6 below.

Table2.6 Comprehensive viva-voce(External)-components and weightage

Components	Weightage
Subject of special interest, fundamental physics, topics covering all semesters and awareness of current and advanced topics.	15
Total	**15**

Both project evaluation and viva voce examination are to be conducted in batches of students formed for the practical examinations.

2.3.3 Reappearance/Improvement: For reappearance/ improvement as per university rules, students can appear along with the next regular batch of students of their particular semester. A maximum of two chances will be given for each failed paper. Only those papers in which candidate have failed need be repeated. Chances of reappearance will be available only during eight continuous semesters starting with the semester in which admission/readmission is given to the candidate.

2. Evaluation Second stage– Calculation of Grade Point Average **(GPA)** of a course (to be done by the University)

3. Evaluation Third stage -Semester Grade Point Average **(SGPA)** (to be done by the University)

4. Evaluation- Fourth stage - Cumulative Grade Point Average**(CGPA)** (to be done by the University)

CHAPTER III

3. M.Sc. PHYSICS SYLLABUS

3.1 INTRODUCTION

This chapter deals with the syllabi of all core courses, Elective courses of the MSc. Physics program. The semester wise distribution of the courses is given.

In the semester III and semester IV, the courses from elective bunch will come as opted by the colleges concerned.

3.2 CORE COURSES

SEMESTER I

PH010101: MATHEMATICAL METHODS IN PHYSICS – I

Total Credits: 3

Total Hours: 54

Objective of the course: The objective of this course is to make students have an idea of vector, matrices and tensors, it's physical interpretation and applications.

UNIT I

Vector analysis (8 hrs)

1.1 Line, Surface and Volume integrals1.2 Gradient, divergence and curl of vector Functions 1.3Gauss Divergence Theorem 1.4 Stoke's Theorem1.5Green's Theorem1.6 Potential Theory1.6.1 Scalar Potential-Gravitational Potential, Centrifugal Potential

Curvilinear co-ordinates(8 hrs)

1.7 Transformation of co-ordinates1.8 Orthogonal Curvilinear co-ordinates1.9Unit Vectors in curvilinear systems1.10Arc Length and Volume Elements1.11Gradient, Divergence and Curl in orthogonal curvilinear co-ordinates1.12 Special Orthogonal co-ordinates system 1.12.1 Rectangular Cartesian Co-ordinates 1.12.2 Cylindrical Co-ordinates 1.12.3Spherical Polar Co-ordinates

UNIT II

Linear vector space(8 hrs)

1.1 Definition of linear vector space 2.2 Inner product of vectors 2.3basis sets 2.4Gram schmidt ortho normalization 2.5Expansion of an arbitrary vector2.6Schwarz inequality

Probability theory and distribution(6 hrs)

2.7 Elementary Probability Theory 2.8 Binomial Distribution2.9 Poisson Distribution 2.10 Gaussian Distribution 2.11Central Limit Theorem

UNIT III

Matrices(12hrs)

3.1 Direct Sum and Direct Product of Matrices 3.2 Diagonal matrices 3.3 Matrices inversion (Gauss Jordan Inversion Methods) 3.4 Orthogonal, unitary and Hermitian Matrices 3.5 Pauli spin matrices, Dirac matrices, Normal matrices 3.6 Cayley Hamilton Theorem 3.7 Similarity transformation 3.8 Orthogonal & Unitary Transformations 3.9 Eigen values & Eigen Vectors 3.10 Diagonalization using normalized Eigen vectors 3.11Solution of linear equation Gauss Elimination method

UNIT IV

Tensors(12 hrs)

4.1 Definition of Tensors 4.2 Basic Properties of Tensors 4.3 Covariant, Contra variant & Mixed Tensors 4.4 Kronecker delta, Levi-Civita Tensor 4.5 Metric Tensor and its properties 4.6 Tensor algebra 4.7Associated Tensors 4.8 Christoffel Symbols & their transformation laws 4.9 Covariant Differentiation 4.10Geodesics

Recommended Text Books:

1. Mathematical methods for Physicists, G.B. Arfken& H.J. Weber 5th edition, Academic Press.
2. Mathematical Physics , V.Balakrishnan, Ane Books Pvt Limited
3. Introduction to Mathematical Physics – Charles Harper, PHI
4. Vector Analysis & Tensor Analysis – Schaum's Outline Series, M.R.Speigel, Mc Graw hill
5. Mathematical methods for physics and engineering, K F Riley, M P Hobson, S J Bence, Cambridge university press.

Recommended References:

1. An Introduction to Relativity, Jayant V. Narliker,Cambridge University Press.
2. Advanced Engineering Mathematics E.Kreyszig 7^{th}edition John Wiley
3. Mathematical Physics, B.S.Rajput,Y.Prakash 9^{th} editionPragatiPrakashan
4. Mathematical Physics, B.D.Gupta ,Vikas Publishing House
5. Matrices and tensors in Physics, A.W.Joshi
6. Mathematical Physics , P.K.Chatopadhyay ,New Age International Publishers
7. Mathematical Physics, Sathyaprakash, Sultan Chand & Sons

PH010102: CLASSICAL MECHANICS

Total Credits: 4

Total Hours: 72

Objective of the course:

After completing the course, the students will (i) understand the fundamental concepts of the Lagrangian and the Hamiltonian methods and will be able to apply them to various problems; (ii) understand the physics of small oscillations and the concepts of canonical transformations and Poisson brackets ; (iii) understand the basic ideas of central forces and rigid body dynamics; (iv) understand the Hamilton-Jacobi method and the concept of action-angle variables. This course aims to give a brief introduction to the Lagrangian formulation of relativistic mechanics.

UNIT 1

Lagrangian formulation (14 hrs)

1.1 Review of Newtonian Mechanics: Mechanics of a Particle; Mechanics of a System of Particles; Constraints; 1.2 D' Alembert's principle and Lagrange's equations; velocity-Dependent potentials and the Dissipation Function; Lagrangian for a charged particle in electromagnetic field; 1.3 Application of Lagrange's equation to: motion of a single particle in Cartesian coordinate system and plane polar coordinate system; bead sliding on a rotating wire.1.4 Hamilton's Principle; Technique of Calculus of variations; The Brachistochrone problem. 1.5 Derivation of Lagrange's equations from Hamilton's Principle. 1.6 Canonical momentum; cyclic coordinates; Conservation laws and Symmetry properties- homogeneity of space and conservation of linear momentum; isotropy of space and conservation of angular momentum; homogeneity of time and conservation of energy; Noether's theorem(statement only; no proof is expected).

Hamiltonian formulation: (4hrs)

1.7 Legendre Transformations; Hamilton's canonical equations of motion; Hamiltonian for a charged particle in electromagnetic field. 1.8 Cyclic coordinates and conservation theorems; Hamilton's equations of motion from modified Hamilton's principle

UNIT II

Small oscillations (8hrs)

2.1 Stable equilibrium unstable equilibrium and neutral equilibrium; motion of a system near stable equilibrium-Lagrangian of the system and equations of motion. 2.2 Small oscillations- frequencies of free vibrations; normal coordinates and normal modes 2.3 system of two coupled pendula-resonant frequencies normal modes and normal coordinates ;free vibrations of CO_2 molecule- resonant frequencies normal modes and normal coordinates.

Canonical transformations and poisson brackets (10 hrs)

2.4 Equations of canonical transformations; Four basic types of generating functions and the corresponding basic canonical transformations. Examples of canonical transformations - identity transformation and point transformation. 2.5 Solution of harmonic oscillator using canonical transformations.

2. 6 Poisson Brackets ; Fundamental Poisson Brackets; Properties of Poisson Brackets 2.7 Equations of motion in Poisson Bracket form; Poisson Bracket and integrals of motion; Poisson's theorem; Canonical invariance of the Poisson bracket.

UNIT III

Central force problem (9hours)

3.1 Reduction of two-body problem to one-body problem; Equation of motion for conservative central forces - angular momentum and energy as first integrals; law of equal areas 3.2 Equivalent one-dimensional problem –centrifugal potential; classification of orbits. 3.3 Differential Equations for the orbit; equation of the orbit using the energy method; The Kepler Problem of the inverse square law force;

Scattering in a central force field - Scattering in a Coulomb field and Rutherford scattering cross section.

Rigid body dynamics (9hrs)

3.4 Independent coordinates of a rigid body; Orthogonal transformations ; Euler Angles. 3.5 Infinitesimal rotations: polar and axial vectors; rate of change of vectors in space and body frames; Coriolis effect. 3.6 Angular momentum and kinetic energy of motion about a point; Inertia tensor and the Moment of Inertia; Eigenvalues of the inertia tensor and the Principal axis transformation . 3.7 Euler equationsof motion; force free motion of a symmetrical top.

UNIT IV

Hamilton-Jacobi theory and action-angle variables(12 hrs)

4.1 Hamilton-Jacobi Equation for Hamilton's Principal Function; physical significance of the principal function. 4.2 Harmonic oscillator problem using the Hamilton-Jacobi method. Hamilton-Jacobi Equation for Hamilton's characteristic function 4.3 Separation of variables in the Hamilton-Jacobi Equation; Separability of a cyclic coordinate in Hamilton-Jacobi equation; Hamilton-Jacobi equation for a particle moving in a central force field(plane polar coordinates) . 4.4 Action-Angle variables; harmonic oscillator problem in action-angle variables.

Classical mechanics of relativity (6 hrs.)

4.5 Lorentz transformation in matrix form; velocity addition; Thomas precession. 4.6 Lagrangian formulation of relativistic mechanics; Application of relativistic Lagrangian to (i)motion under a constant force (ii) harmonic oscillator and (iii) charged particle under constant magnetic field.

Recommended Text Books

1. Classical Mechanics: Herbert Goldstein , Charles Poole and John Safko, (3/e); Pearson Education.
2. Classical Mechanics: G. Aruldhas, Prentice Hall 2009.

Recommended References:

1. Theory and Problems of Theoretical Mechanics (Schaum Outline Series): Murray R. Spiegel, Tata McGraw-Hill 2006.

2. Classical Mechanics : An Undergraduate Text: Douglas Gregory, Cambridge University Press.
3. Classical Mechanics: Tom Kibble and Frank Berkshire, Imperial College Press.
4. Classical Mechanics (Course of Theoretical Physics Volume 1): L.D. Landau and E.M. Lifshitz, Pergamon Press.
5. Analytical Mechanics: Louis Hand and Janet Finch, Cambridge University Press.
6. Classical Mechanics: N.C.Rana and P. S. Joag, Tata Mc Graw Hill.
7. Classical Mechanics: J.C. Upadhyaya, Himalaya Publications, 2010.
8. www.nptelvideos.in/2012/11/classicalphysics.html.

PH010103: ELECTRODYNAMICS

Total credits: 4

Total hours: 72

Objective of the course**:** Electromagnetic force is one of the four forces that exist in nature with a prominent role in the daily activities of human being. So it is necessary to know the physics of this force from the basics of two inter twinned phenomena called electricity and magnetism. Hence the course aims to impart proper understanding of electricity magnetism and electrodynamics; wave nature of electromagnetic field and its properties; electromagnetic field radiating out of accelerated charges and the impact of relativity in electromagnetism along with confined propagation of electromagnetic wave.

UNIT 1

Electrostatics, Magnetostatics and basics of Electrodynamics(18 hrs)

1.1 Electrostatics: Electric field of a polarized object- Electric field in a - conductor-dielectric - electric displacement -Gauss's law in dielectric medium-linear dielectric medium-. Boundary condition across dielectric (ε_{r1})-dielectric (ε_{r2}), conductor-dielectric (ε_r), conductor-free space (ε_r=1) interface. 1.2 Uniqueness theorem and electrostatic potential-Solving Poisson's and Laplace equations for boundary value problems 1.3 Method of images- point charge -line charge above a grounded conducting plane. 1.4 Potential at large distance-multipole expansion due to a localized charge distribution-Electric field of a dipole. 1.5 Magnetostatics: Biot-Savart law- divergence and curl of B- Ampere’s law. Magnetic vector potential-multipole expansion of vector potential-boundary conditions - Magnetic field inside matter- Magnetization (M)-Magnetic flux density (B)-Auxiliary field (H). 1.6 Electrodynamics: Electromotive force - motional emf - Faraday’s law-, electrodynamic equations - displacement current. 1.7 Uniform sinusoidal time varying fields E and B and Maxwell’s equations in free space and matter. Boundary conditions of electric and magnetic field 1.8 Conservation laws- continuity equation- Poynting’s theorem-Maxwell’s stress tensor- momentum conservation.

UNIT II

Electromagnetic waves (18 hrs)

1.1Wave equation for E and B- monochromatic plane waves- energy- momentum 1.2 Propagation of em waves through linear media- Reflection and transmission of a plane wave at normal - oblique incidence.1.3 Electromagnetic waves in a conducting medium. Reflection at conducting surface- frequency dependence of permittivity 1.4 Dispersion of electromagnetic waves in non-conductors, conductors and plasma medium

UNIT III

Electromagnetic radiation (18 hrs)

3.1Potential formulation of electrodynamics- Gauge transformations-Coulomb and Lorentz gauge 3.2 Continuous charge distribution-Retarded potential-Jefmenko’s equation.3.3 Point charges- Lienard-Wiechert potentials-Field of a point charge in motion- Power radiated by a point charge 3.4 Electric dipole radiation-magnetic dipole radiation-radiation from arbitrary distribution of charges 3.5 Radiation reaction-Abraham-Lorentz formula.

UNIT IV

Relativistic electrodynamics and Waveguides (18 Hrs)

4.1Relativistic electrodynamics 4.1.1 Structure of spacetime- Four vectors-Proper time and proper velocity- Relativistic energy and momentum-Relativistic dynamics- Minkowski force. 4.1.2 Magnetism as a relativistic phenomenon. 4.1.3 Lorentz transformation of em field- field tensor-electrodynamics in tensor notation. 4.1.4 Potential formulation of relativistic electrodynamics. 4.2 Waveguides 4.2.1 Waves between parallel planes-TE-TM-TEM waves4.2.2 Rectangular waveguide- TE-TM waves -impossibility of TEM wave. 4.2.3 Cylindrical waveguide- TE-TM waves

Recommended textbooks:

1. Introduction to Electrodynamics, David J. Griffiths, PHI.
2. Electromagnetics, John D.Kraus, McGraw-Hill International
3. Classical electrodynamics, J.D Jackson, John Wiley & Sons Inc

Recommended References:

1. Electromagnetic waves and radiating systems Edward C Jordan, Keith G Balamin, Printice Hall India Pvt.Ltd
2. Elements of Electromagnetic, Mathew N. O Sadiku, Oxford University Press
3. Antenna and wave propagation, K.D Prasad, Satyaprakashan, New Delhi
4. Electromagnetism problems with solutions, Ashutosh Pramanik, PHI.

PH010104: ELECTRONICS

Total credits: 4

Total hours: 72

Objective of the course: Electronics is the study of the flow of charge (electron) through various materials and devices such as semiconductors, resistors, inductors, capacitors, nanostructures etc. All applications of electronics involve the transmission of power and possibly information.

UNIT I

Op-amp with Negative Feedback (16 Hrs)

1.1. Differential amplifier – Inverting amplifier – Non-inverting amplifier **-**Block diagram representations – Voltage series feedback: Negative feedback – closed loop voltage gain 1.2. Difference input voltage ideally zero – Input and output resistance with feedback – Bandwidth with feedback – Total output offsetvoltagewithfeedback– Voltagefollower.1 . 3 v o l t a g e shuntfeedback amplifier: Closed loop voltage gain -inverting input terminal and virtual ground - input and output resistance with feedback – Bandwidth with feedback - Total output offset voltage with feedback.1.4. Current to voltage converter- Inverter.Differential amplifier with one op-amp and two op-amps.

UNIT II

The Practical Op-amp (6 Hrs)

2.1. Input offset voltage –Input bias current – input offset current – Total output offset voltage- Thermal drift.2.2. Effect of variation in power supply voltage on offset voltage – Change in input offset voltage and input offset current with time - Noise – Common mode configuration and CMRR.

General Linear Applications (with design) (14Hrs)

2.3. DC and AC amplifiers – AC amplifier with single supply voltage – Peaking amplifier – Summing, Scaling, averaging amplifiers.2.4. Instrumentation amplifier using transducer bridge. Differential input and differential output amplifier – Low voltage DC and AC voltmeter. 2.5. Voltage to current converter with grounded load – Current to voltage converter. 2.6. Very high input impedance circuit – integrator and differentiator.

UNIT III

Frequency Response of an Op-amp (6 Hrs)

3.1. Frequency response –Compensating networks – Frequency response of internally compensated and non-compensated op-amps – High frequency op- amp equivalent circuit.3.2. Open loop gain as a function of frequency – Closed loop frequency response – Circuit stability - slew rate.

Active Filters and Oscillators. (with design) (12Hrs)

3.3. Active filters – First order and second order low pass Butterworth filter3.4 First order and second order high pass Butterworth filter.3.5. Wide and narrow band pass filter - wide and narrow band reject filter. All pass filter – Oscillators: Phase shift and Wien-bridge oscillators. 3.6. Square, triangular and sawtooth wave generators- Voltage controlled oscillator.

UNIT IV

Comparators and Converters (8 Hrs)

4.1. Basic comparator- Zero crossing detector.4.2. Schmitt Trigger – Comparator characteristics- Limitations of op-amp as comparators. 4.3. Voltage to frequency and frequency to voltage converters.4.4. D/A and A/D converters- Peak detector – Sample and Hold circuit.

IC555 Timer (**3 Hrs**)

4.5.IC555 Internal architecture, Applications IC565-PLL, Voltage regulator ICs 78XX and 79XX

Analog Communication (7 Hrs)

4.6. Review of analog modulation – Radio receivers – AM receivers – superhetrodyne receiver.4.8. Detection and automatic gain control – communication receiver. 4.9. FM receiver – phase discriminators – ratio detector – stereo FM reception

Recommended Text Books:

1. Op-amps and linear integrated circuits R.A. Gayakwad 4^{th}Edn.PHI
2. Electronic Communication Systems, Kennedy& Davis 4^{th}Ed.TMH,

Recommended References:

1. Electronic Devices (Electron Flow Version), 9/E Thomas L. Floyd, Pearson
2. Fundamentals of Electronic Devices and Circuits 5^{th} Ed. David A. Bell, Cambridge.

PH010105:GENERAL PHYSICS PRACTICALS

Total credits: 4

Total hours: 180

** Minimum number of experiments to be done 12*

***Error analysis of the result is a compulsory part of experimental work*

1. Hall Effect in Semiconductor. Determine the Hall coefficient, carrier concentration and carrier mobility.
2. Ultrasonic- acoustic optic technique-elastic property of a liquid.
3. Magnetic susceptibility of a paramagnetic solution using Quinck's tube method.
4. Curie temperature of a magnetic material.
5. Dielectric Constant and Curie temperature of ferroelectric Ceramics.
6. Draw the hysteresis curve (B – H Curve) of a ferromagnetic material and determination of retentivity and coercivity.
7. Cornu's method- Determination of elastic constant of a transparent material
8. Determination of e/m by Thomson's method.
9. Determination of e/k of Silicon.
10. Determination of Planck's constant (Photoelectric effect).
11. Measurement of resistivity of a semiconductor by four-probe method at different temperature and determination of band gap.
12. Determination of magnetic susceptibility of a solid by Guoy's method.
13. Measurement of wavelength of laser using reflection grating.
14. Fraunhoffer diffraction pattern of a single slit, determination of wavelength/slit width.
15. Fraunhoffer diffraction pattern of wire mesh, determination of wavelength/slit width.
16. Fraunhoffer diffraction pattern of double slit, determination of wavelength/slit width.
17. Diffraction pattern of light with circular aperture using Diode/He-Ne laser.
18. Fresnel diffraction pattern of a single slit.

19. Study the beam divergence, spot size and intensity profile of Diode/He-Ne laser.
20. Determine the numerical aperture of optical fibre and propagation of light through it.
21. Determine the refractive index of the material using Brewster angle setup.
22. Absorption bands of $KMnO_4$ using incandescent lamp. Determine the wave lengths of the absorption bands. Determine the wave lengths of the absorption bands by evaluating Hartman's constants.
23. Determine the co-efficient of viscosity of the given liquid by oscillating disc method.
24. Measure the thermoemf of a thermocouple as function of temperature. Also prove that Seebeck effect is reversible.
25. Determine the Young's modulus of the material of a bar by flexural vibrations.
26. Using Michelson interferometer determine the wavelength of light.
27. Study the temperature dependence of dielectric constant of a ceramic capacitor and verify Curie-Wiess law
28. Study the dipole moment of an organic molecule (acetone).
29. Determine the dielectric constant of a non-polar liquid.
30. Photograph/Record the absorption spectrum of iodine vapour and a standard spectrum.Analyze the given absorption spectrum of iodine vapour and determine the convergence limit. Also estimate the dissociation energy of iodine (wave number corresponding to the electronic energy gap = 759800 m^{-1})
31. Determine the dielectric constant of a non-polar liquid.
32. Determine the charge of an electron using Millikan oil drop experiment.
33. Linear electro optic effect(Pockel effect), Frank Hertz experiment.
34. Frank Hertz experiment determination of ionization potential.
35. Koening's method, Poisson's ratio of the given material of bar.
36. Determination of Stefan's constant of radiation from a hot body.

References

R1. Advanced practical physics for students, B.L Worsnop and H.T Flint, University of California.

R2. A course on experiment with He-Ne Laser, R.SSirohi, John Wiley & Sons (Asia) Pvt.ltd

R3. Kit Developed for doing experiments in Physics- Instruction manual, R.Srenivasan ,K.R Priolkar, Indian Academy of Sciences.

R4. Advanced Practical Physics, S.P singh, PragatiPrakasan,

R5. Practical Physics, Gupta, Kumar, PragatiPrakasan.

R6. An advanced course in Practical Physics, D.Chattopadhayay, C.R Rakshit, New Central Book Agency Pvt. Ltd: ****for error analysis only.**

SEMESTER II

PH010201:MATHEMATICAL METHODS IN PHYSICS – II

Total Credits: 4

Total Hours: 72

Objective of the course: Introduce the concepts of Laplace and Fourier transforms. Introduce the Fourier series and it's application to solutions of partial differential equations.

UNIT 1

Complex analysis (18 hrs)

1.1Functions of a complex variable 1.2 Analytic functions1.3Cauchy-Riemann equation1.4Integration in a complex plane1.5Cauchy Theorem 1.6 Cauchy's integral formulas 1.7 Taylor expansion & Laurent expansion1.8 Residue, poles1.9 Cauchy residue theorem1.10 Cauchy's principle value theorem 1.11 Evaluation of integrals

UNIT II

Integral transforms (18 hrs)

2.1 Fourier Series 2.2 Application of Fourier series 2.2.1 Square Wave 2.2.2 Full Wave Rectifier 2.3 Fourier Integral 2.4 Fourier Transform 2.4.1 Finite Wave Train 2.5 Convolution Theorem of parseval's relation2.6Momentum representation 2.6.1 Hydrogen atom 2.6.2 Harmonicoscillator 2.7 Laplace Transform, Inverse Laplace transform 2.8 Earth Mutation 2.9 Damped Oscillator 2.10 LCR circuit

UNIT III

Special functions and differential equations (18 hrs)

3.1 Gamma Function 3.2 Beta Function 3.3 Symmetry Property of Functions 3.4 Evaluation of Beta functions3.5 Other forms of Beta Functions --Transformation of P Functions 3.6 Evaluation of Gamma Functions 3.7 Other forms of Gamma Functions- Transformation of Gamma Functions 3.8 Relation between Beta and Gamma Functions 3.9 Evaluation of Integrals 3.10 Bessel's Differential Equation, 3.11 Legendre Differential Equation 3.12 Associated Legendre Differential Equations 3.13 Hermite Differential Equations 3.14 Laguerre Differential Equations (Generating function, recurrence relation, orthogonality condition, Rodrigues formulae for all functions)

UNIT IV

Partial differential equations (18 hrs)

4.1 Characteristics of boundary conditions for partial differential equation 4.2 Solution of partial differential equations by the method of separation of variables in Cartesian, cylindrical and spherical polar co-ordinates 4.3 Solution of Laplace equation in cartesian, cylindrical and spherical polar co-ordinates4.4Heat equation in Cartesian co-ordinates 4.5 Non-Homogeneous equation 4.6 Green's function 4.7 Symmetry of Green's Function4.8Green's Function for Poisson Equation, Laplace equation, Helmholtz equation 4.9Application of Greens equation in scattering problem

Recommended Text Books:-

1. Mathematical methods for Physicists, G.B. Arfken& H.J. Weber 5th edition, Academic Press.
2. Mathematical Physics , V.Balakrishnan,Ane Books Pvt Limited

Recommended Reference Books:

1. Advanced Engineering Mathematics E.Kreyszig 7th edition John Wiley
2. Mathematical Physics, B.S.Rajput,Y.Prakash 9th edition PragatiPrakashan
2. 3.Mathematical Physics,B.D.Gupta ,Vikas Publishing House
3. 4.Matrices and tensors in Physics,A.W.Joshi
4. 5.Mathematical Physics , P.K.Chatopadhyay ,New Age International Publishers
5. 6.Mathematical Physics, Sathyaprakash, Sultan Chand & Sons

PH010202 QUANTUM MECHANICS-I

Total Credits: 4

Total Hours: 54

Objective of the course:

This course aims to develop the basic structure of quantum Mechanics. After completing the course, the student will (i) understand the fundamental concepts of the Dirac formalism (ii) understand how quantum systems evolve in time; (iii) understand the basics of the quantum theory of angular momentum. Also, this course enable the student to solve the hydrogen atom problem which is a prelude to more complicated problems in quantum mechanics.

UNIT I

Basics Formulation of Quantum Mechanics (20 hours)

1.1 Development of the idea of state vectors from sequential Stern-Gerlach experiments ;Dirac notation for state vectors: ket space, bra space and inner products; 1.2 Operators; Associative axiom; outer product; 1.3 Hermitian adjoint; Hermitian operator; Eigenkets and eigenvalues of Hermitian operators. Eigenkets of observables as base kets; concept of complete set. Projection operators. 1.4 Matrix representations of operators, kets and bras 1.5 Measurements in quantum mechanics; expectation value ; Compatible observables and existence of simultaneous eigenkets; General Uncertainty Relation. 1.6 Unitary operator, change of basis and transformation matrix, unitary equivalent observables. 1.7 Position eigenkets, infinitesimal translation operator and its properties, linear momentum as generator of translation, canonical commutation relations. Wavefunction as an expansion coefficient; eigenfunctions, momentum eigen function 1.8 momentum space wavefunctions and the relation between wavefunctions in position space and momentum space. Gaussian wave packet- compuatation of dispersions in position and momentum.

UNIT II

Quantum Dynamics (16 hours)

2.1 Time evolution operator and its properties 2.2 Schrodinger equation for the time evolution operator; solution of the Schrodinger equation for different time dependences of the Hamiltonian 2.3 Energy eigenkets; time dependence of expectation values 2.4 time evolution of a spin half system and spin precession 2.5 Correlation amplitude; time-energy uncertainty relation and its interpretation.

2.6 Schrodinger picture and Heisenberg picture; behavior of state kets and observables in Schrodinger and Heisenberg pictures; Heisenberg's equation of motion 2.7 Ehrenfest's theorem; time evolution of base kets; transition amplitudes. 2.8 Simple Harmonic Oscillator: Energy eigenvalues and energy eigenkets.

UNIT III

Theory of Angular Momentum (14 hours)

3.1 Non-commutativity of rotations around different axes; the rotation operator; fundamental commutation relations for angular momentum operators 3.2 rotation operators for spin half systems; spin precession in a magnetic field 3.3 Pauli's two component formalism; 2X2 matrix representation of the rotation operator 3.4 ladder operators; eigenvalue problem for angular momentum operators 3.5 matrix representation of angular momentum operators.3.6 Orbital angular momentum ; orbital angular momentum as a generator of rotation 3.7 Addition of orbital angular momentum and spin angular momentum; addition of angular momenta of two spin-1/2 particles. General theory of Angular Momentum addition-Computation of Clebsch - Gordon coefficients.

UNIT IV

The Hydrogen Atom (4 hours)

4.1 Behaviour of the radial wavefunction near the origin; the Coulomb potential and the hydrogen atom; hydrogenicwavefunctions; degeneracy in hydrogen atom.

Recommended Text Books:

1. Modern Quantum Mechanics   : J. J. Sakurai, Pearson Education.
2. A Modern Approach to Quantum Mechanics: J S Townsend, Viva Books.

Recommended References:

1. Quantum Mechanics (Schaum's Outline) :Yoav Peleg *etal*. Tata Mc Graw Hill Private Limited, 2/e.

2. Quantum Mechanics: 500 Problems with Solutions: G Aruldhas, Prentice Hall of India.
3. Quantum Mechanics Demystified: David McMohan, McGrawHill 2006.
4. Introductory Quantum Mechanics: Richard L Liboff, Pearson Education .
5. Introduction to Quantum Mechanics: D.J. Grifith, Pearson Education.
6. Quantum Mechanics : V. K. Thankappan, New Age International.
7. Quantum Mechanics: An Introduction: Walter Greiner and Allan Bromley, Springer.
8. Quantum Mechanics : Non-Relativistic Theory(Course of Theoretical Physics Vol3): L. D. Landau and E. M. Lifshitz, Pregamon Press.
9. The Feynman Lectures on Physics Vol3, Narosa.
10. www.nptel/videos.in/2012/11/quantum-physics.html
11. https://nptel.ac.in/courses/115106066/

PH010203 STATISTICAL MECHANICS

Total Credits: 4

Total Hours: 72

UNIT I (22 hrs)

1.1. The Statistical Basis of Thermodynamics1.1.1. Macroscopic and microscopic states.1.1.2.Connection between thermodynamics and statistics.1.1.3.Classical ideal gas.1.1.4.Entropy of mixing and Gibbs paradox.1.1.5. Correct enumeration of micro states.1.2. Elements of Ensemble Theory 1.2.1. Phase space of a classical system.

1.2.2. Liouville’s theorem.1.2.3. Micro-canonical ensemble.1.2.4. Quantum states and phase space.1.3. Canonical ensemble.1.3.1. Equilibrium between a system and a heat reservoir.1.3.2. System in canonical ensemble.1.3.3. Physical significance of statistical quantities in canonical ensemble.1.3.4. Classical systems.1.3.5. Energy fluctuations in canonical ensemble.1.3.6.Equipartition theorem.

UNIT II(18 hrs)

2.1. Grand canonical Ensemble2.1.1. Equilibrium between system and energy-particle reservoir.2.1.2.A system in grand canonical ensemble.2.1.3.Physical significance of various statistical quantities.2.1.4. Examples.2.1.5. Fluctuations in grand canonical ensemble.2.2. Formulation of Quantum Statistics2.2.1.Quantum mechanical ensemble theory.2.2.2.Density matrix.2.2.3.Statistics of various ensembles.2.2.4.Examples (an electron in magnetic feilds, free particle in a box).

2.2.5. A system composed of indistinguishable particles.

UNIT III(22hrs)

3.1. Quantum Theory of Simple Gases3.1.1. Ideal gas in quantum-micro canonical ensemble.3.1.2.Ideal gas in other quantum mechanical ensembles.3.1.3.Statistics of the occupation numbers3.2.Ideal Bose Systems3.2.1.Thermodynamic behaviour of ideal Bose gas.3.2.2.Thermodynamics of black body radiation. The field of sound waves .3.3. Ideal Fermi Systems3.3.1.Thermodynamics of ideal Fermi gas.3.3.2.Magnetic behaviour of ideal fermi gas.3.3.3.Electron gas in metals.4.

UNIT IV(10 hrs)

4.1. Phase Transitions4.1.1. Phases.4.1.2. Thermodynamic potentials, 4.1.3. Approximation.4.1.4. First order phase transition.4.1.5. Clapeyron equation.

Recommended Text books:

1. Text book- R.K. Pathria, Statistical Mechanics, second edition (1996), Butterworth, Heinemann. (For Modules I, II and III.)
2. R Bowley and M. Sanchez, Introductory Statistical Mechanics, second edition, Oxford University Press. (For Module IV)

Recommended Reference Books:

1. Kerson Huang, Statistical Mechanics, John Wiley and Sons (2003).
2. F. Rief, Fundamentals of Statistical and Thermal Physics, McGraw Hill (1986).
3. D. Chandler, Introduction to Statistical Mechanics, Oxford University Press (1987)
4. L.D Landau and E.M Lifshitz, Statistical Physics (Vol-1),3rd Edition. Pergamon Press(1989)
5. Yung-Kuo Lim, Problems and Solutions in Thermodynamics and Statistical Mechanics, World Scientific (1990).

PH010204: CONDENSED MATTER PHYSICS

Total Credits: 4

Total Hours: 72

UNIT 1

Wave Diffraction and the Reciprocal Lattice (5Hrs)

1.1 Diffraction of waves by crystals-Bragg's Law- **1.2** Scattered wave amplitude-reciprocal lattice vectors- diffraction condition-Laue equations-Ewald construction- **1.3** Brillouin zones- reciprocal lattice to SC, BCC and FCC lattices-properties of reciprocal lattice- **1.4** diffraction intensity - structure factor and atomic form factor-physical significance.

Crystal Symmetry (7Hrs)

1.5 Crystal symmetry-symmetry elements in crystals-point groups, space groups

1.6 Ordered phases of matter-translational and orientational order- kinds of liquid crystalline order-Elements of Quasi crystals

Free Electron Fermi Gas (12 Hrs)

1.7. Energy levels in one dimension-quantum states and degeneracy- density of states- **1.8** Fermi-Dirac statistics -Effect of temperature on Fermi-Dirac distribution –**1.9** Free electron gas in three dimensions- **1.10** Heat capacity of the electron gas- relaxation time and mean free path - **1.11** Electrical conductivity and Ohm's law - Widemann-Franz-Lorentz law - electrical resistivity of metals.

UNIT II

Energy Bands (8 Hrs)

2.1 Nearly free electron model- Origin of energy gap-Magnitude of the Energy Gap- **2.2** Bloch functions – **2.3** Kronig-Penney model –**2.4** Wave equation of election in a periodic potential-Restatement of Bloch theorem-Crystal momentum of an Electron-Solution of the central equations-**2.5** Brillouin zone- construction of Brillouin zone in one and two dimensions – extended, reduced and periodic zone scheme of Brillouin zone (qualitative idea only) - **2.6** Effective mass of electron –**2.7** Distinction between conductors, semiconductors and insulators.

Semiconductor Crystals (10 Hrs)

2.8. Band Gap-**2.9.**Equations of motion-Effective mass-Physical interpretation of effective mass - Effective mass in semiconductors-Silicon and Germanium-**2.10** Intrinsic carrier concentration- **2.11** Impurity conductivity-Thermal ionization of Donors and Acceptors-Thermoelectric effects-semimetals-super lattices-Bloch Oscillator-Zener tunnelling.

UNIT III

Phonons

Crystal Vibrations and Thermal Properties (16 Hrs)

3.1 Vibrations of crystals with monatomic basis –First Brillouin zone-Group Velocity-**3.2** Two atoms per Primitive Basis – **3.3** Quantization of elastic waves –**3.4** Phonon momentum-**3.5** Inelastic scattering of phonons.-**3.6** Phonon Heat Capacity-Plank distribution-Density of States in one and three dimensions-Debye model for density of states-Debye T^3 Law-Einstein Model for Density of states- **3.7** Anharmonic Crystal interactions-Thermal Expansion- **3.8** Thermal Conductivity-thermal resistivity of phonon gas-Umklapp Processes-Imperfections

UNIT IV

Magnetic Properties of Solids (14 hrs)

4.1 Quantum theory of paramagnetism–Hunds rules-crystal field splitting-spectroscopic splitting factor-**4.2** Cooling by adiabatic demagnetization – Nuclear Demagnetization- **4.3** Ferromagnetic order-Curie point and the exchange integral-Temperature dependence of the saturation-Magnetization-Saturation Magnetization at absolute Zero-**4.4** Magnons- Quantization of spin waves-Thermal excitation of Manganons-**4.5** Neutron Magnetic Scattering-**4.6** Ferromagnetic order-curie temperature and Susceptibility-**4.7** Antiferromagnetic order-susceptibility below Neel-Temperature-**4.8** Ferromagnetic domains-Anisotropic Energy-transition region between Domains-origin of domains - Corecivity and Hysteresis-**4.9** Single Domain Particles-Geomagnetism and Biomagnetism-Magnetic scope microscopy **4.10** Elements of superfluidity

Recommended Textbooks:

1. Introduction to Solid State Physics, Charles Kittel, Wiely, Indian reprint (2015).
2. Solid State Physics, A.J. Dekker, Macmillan & Co Ltd. (1967)
3. Introduction to Solids, L V Azaroff, McGRAW-HILL BOOK COMPANY, INC.New York (1960)

Recommended References:

1. Solid State Physics, N.W. Ashcroft & N.D. Mermin, Cengage Learning Pub.11th IndianReprint (2011).
2. Solid State Physics, R.L. Singhal, KedarNath Ram Nath& Co (1981)
2. Elementary Solid State Physics, M. Ali Omar, Pearson, 4th Indian Reprint (2004).
3. Solid State Physics, C.M. Kachhava, Tata McGraw-Hill (1990).
4. Elements of Solid State Physics, J. P. Srivastava, PHI (2004)
5. Solid State Physics, Dan Wei, Cengage Learning (2008)
6. Solid State Physics, J S Blackemore, Cambridge University Press (1985)
2. 8.Electronic Properties of Crystalline Solids, Richard Bube, Academic Press New York (1974)

PH010205:ELECTRONICS PRACTICAL

Total credit: 4

Total hours: 180

* *Minimum number of experiments to be done 12*

*******Error analysis of the result is a compulsory part of experimental work*

*** *PC interfacing facilities such as ExpEYES can be used for the experiments*

1. Op-Amp parameters (i) Open loop gain (ii) input offset voltage (iii) input bias current (iv)) CMRR (v) slew rate (vi) Band width
2. Design and construct an integrator using Op-Amp (*μA741)*, draw the input output curve and study the frequency response.
3. Design and construct a differentiator using Op-Amp (*μA741) for sin wave and square wave input* and study the output wave for different frequencies.

4. Design and construct a logarithmic amplifier using Op-Amp (*μA741) and study the output wave form*.
5. Design and construct a square wave generator using Op-Amp (*μA741) for a frequency* f_0.
6. Design and construct a triangular wave generator using (*μA741) for a frequency* f_0.
7. Design and construct a saw tooth wave generator using Op-Amp (*μA741)* generator.
8. Design and construct an Op-Amp Wien bridge oscillator with amplitude stabilization and study the output wave form.
9. Design and construct a Schmidt trigger using Op-Amp μA741, *plot of the hysteresis curve.*
10. Design and construct an astable multivibrator using *μA741 with duty cycle other than 50%*
11. Design and construct a RC phase shift oscillator using *μA741for a frequency* f_0.
12. Design and construct a first and second order low pass Butterworth filter using *μA741 and plot the frequency response curve.*
13. Design and construct a first and second order high pass Butterworth filter using *μA741 and study the frequency response.*
14. Design and construct a first order narrow band pass Butterworth filter using *μA741.*
15. Solving differential equation using *μA741*
16. Design and construct ccurrent to voltage and voltage to current converter (*μA741*)
17. Astable multivibrator using 555 timer, study the positive and negative pulse width and free running frequency.
18. Monostable multivibrator using 555 timers and study the input output waveform.
19. Voltage controlled Oscillator using 555 timer
20. Design and construct a Schmitt Trigger circuit using IC 555.
21. Design and test a two stage RC coupled common emitter transistor amplifier and find th bandwidth, mid-frequency gain, input and output impedance.
22. Design and test a RC phase shift oscillator using transistor for a given operating frequency.
23. Voltage controlled Oscillator using transistor

24. Study the function of (i) analog to digital converter using IC 0800 (ii) digital to analog converter DAC 0808
25. Study the application of op-Amp (*μA741) as a d*ifferential amplifier.
26. Solving simultaneous equation using op-Amp (*μA741).*

References:

R1. Op-Amp and linear integrated circuit
Ramakanth A Gaykwad, Eastern Economy Edition, ISBN-81-203-0807-7
R2. Electronic Laboratory Primer a design approach
S. Poornachandra, B.Sasikala, Wheeler Publishing, New Delhi
R3. Electronic lab manual Vol I, K ANavas, Rajath Publishing
R4. Electronic lab manual Vol II, K ANavas, PHI eastern Economy Edition
R5. Electronic lab manual Vol II, Kuriachan T.D, Syam Mohan, Ayodhya Publishing
R6. An advanced course in Practical Physics, D.Chattopadhayay, C.R Rakshit, New Central
Book Agency Pvt. Ltd: ****For error analysis only.**

SEMESTER III

PH010301: QUANTUM MECHANICS-II

Total Credits: 4

Total Hours: 72

Objective of the course:

This course aims to extend the concepts developed in the course ‘ Quantum Mechanics-I . After completing this course, the student will (i) understand the different stationary state approximation methods and be able to apply them to various quantum systems; (ii) understand the basics of time-dependent perturbation theory and its application to semi-classical theory of atom-radiation interaction; (iii) understand the theory of identical particles and its application to helium; (iv) understand the idea of Born approximation and the method of partial waves. Also, this course will introduce the student to the basic concepts of relativistic quantum mechanics.

UNIT I

Approximation Methods for Stationary States(18 hrs)

1.1 Non-degenerate Perturbation Theory: First order energy shift; first order correction to the energy eigenstate; second order energy shift. Harmonic oscillator subjected to a constant electric field. 1.2 Degenerate Perturbation theory First order Stark effect in hydrogen; Zeeman effect in hydrogen and the Lande g-factor.

1.3 The variational Method; Estimation of ground state energies of harmonic oscillator and delta function potential 1.4 Ground State of Helium atom ; Hydrogen Molecule ion.

1.5 The WKB method and its validity; The WKB wavefunction in the classical region; non-classical region ; connection formulas(derivation not required) 1.6 Potential well and quantization condition; the harmonic oscillator. 1.7 Tunneling; application to alpha decay.

UNIT II

Time-Dependent Perturbation Theory (18 hrs)

2.1 Time dependent potentials; interaction picture; time evolution operator in interaction picture; Spin Magnetic Resonance in spin half systems 2.2 Time dependent perturbation theory; Dyson series; transition probability 2.3 constant perturbation; Fermi's Golden Rule ; Harmonic perturbation 2.4 interaction of atom with classical radiation field; absorption and stimulated emission; electric dipole approximation; photoelectric effect 2.5 Energy shift and decay width.

UNIT III

Identical Particles andScattering Theory (18hrs)

3.1 Bosons and fermions; anti-symmetric wave functions and Pauli's exclusion principle. 3.2 The Helium Atom.3.3 The Asymptotic wave function - differential scattering cross section and scattering amplitude 3.4 The Born approximation-scattering amplitude in Born approximation; validity of the Born approximation; Yukawa potential ; Coulomb potential and the Rutherford formula. 3.5 Partial wave analysis- hard sphere scattering; S-wave scattering for finite potential well; Resonances and Ramsauer-Townsend effect .

UNIT IV

Relativistic Quantum Mechanics(18 hrs)

4.1 Klein-Gordon Equation; continuity equation and probability density in Klein-Gordon theory. 4.2 Non-relativistic limit of the Klein-Gordon equation 4.3 Solutions of the Klein –Gordon equation for positive, negative and neutral spin0 particles; Klein-Gordon equation in the Schrodinger form.

4.4 Dirac Equation in the Scrodinger form; Dirac's matrices and their properties 4.5 Solutions of the free particle Dirac equation; single particle interpretation of the plane waves; velocity operator; *zitterbewegung*4.6 Non-relativistic limit of the Dirac equation; spin of Dirac particles; Total angular momentum as a constant of motion. 4.7 Negative energy states and Dirac's hole theory.

Recommended Text Books:

1. Modern Quantum Mechanics: J. J. Sakurai, Pearson Education.
2. A modern Approach to Quantum Mechanics: John Townsend, Viva Books New Delhi
3. Introduction to Quantum Mechanics: D.J. Griffith, Pearson Education
4. Relativistic Quantum Mechanics: Walter Greiner, Springer-Verlag

Recommended References:

1. Quantum Mechanics (Schaum's Outline Series): Yoav Peleg etal., Tata McGraw Hill .Education Private Limited, 2/e.
2. Quantum Mechanics: 500 Problems with Solutions: G Aruldhas, Prentice Hall of India.
3. Problems and Solutions in Quantum Mechanics: Kyriakos Tamvakis, Cambridge University Press.
4. Introductory Quantum Mechanics: Richard L Liboff, Pearson Education.
5. Quantum Mechanics: V. K. Thankappan, New Age International.
6. A Textbook of Quantum Mechanics: P M Mathews and R Venkatesan, Tata McGraw Hill.
7. Quantum Mechanics: Non Relativistic Theory (Course of Theoretical Physics Course Vol3) : L. D. Landau and E. M. Lifshitz, Pregamon Press.

8. Relativistic Quantum Mechanics: James D Bjorken and Sidney D Drell, Tata McGraw Hill 2013
9. www.ntpel/videos.in/2012/11/quantum-physics.html
10. https://nptel.ac.in/courses/115106066/

PH010302: COMPUTATIONAL PHYSICS

Total Credits:4

Total Hours: 72

Objective of the Course:

To help the students to have the basic idea about the techniques used in physics to solve problems with the help of computers when they cannot be solved analytically with pencil and paper since the underlying physical system is very complex. After the completion of this course students might be able to develop their own Algorithms of every method described in the syllabus.

UNIT I
CurveFittingandInterpolation (20Hrs)

1.1 The least squares method for fitting a straight line, 1.2 The least squares method for fitting a parabola, 1.3 The least squares method for fitting a power curves, 1.4 The least squares method for fitting an exponential curves. 1.5 Interpolation - Introduction to finite difference operators,1.6 Newton's forward and backward difference interpolation formula, 1.7 Newton's divided difference formula, 1.8 Cubic spline interpolation.

UNIT II

Numerical Differentiation and Integration(16 Hrs)

2.1 Numerical differentiation, 2.2 cubic spline method,2.3errors in numerical differentiation, 2.4 Integration of a function with Trapezoidal Rule, 2.5 Simpson's 1/3 2.6 Integration of a function with Simpson's 3/8 Rule and error associated with each. 2.7RelevantAlgorithmsforeach.

UNIT III

Numerical Solution of Ordinary Differential Equations (20Hrs)

3.1 Euler method, 3.2 modified Euler method 3.3 Runge - Kutta 4th order methods – 3.4 adaptive step size R-K method, 3.5Higher order equations. 3.6 Concepts of stability.

Numerical Solution of System of Equations

3.7 Gauss-Jordan elimination Method, 3.8 Gauss-Seidel iteration method, 3.9 Gauss elimination method 3.10 Gauss-Jordan method to find inverse of a matrix. 3.11 Power method 3.12 Jacobi's method to solve eigenvalue problems.

UNIT IV

Numerical solutions of partial differential equations (16Hrs)

4.1 Elementary ideas and basic concepts in finite difference method, 4.2 Schmidt Method, 4.3 Crank - Nicholson method,4.4 Weighted average implicit method.

4.5 Monte Carlo evaluation of integrals, 4.6 Buffon’s needle problem, 4.7 requirement for random number generation.

Recommended Text Books:

1. Numerical Methods for Scientists and Engineers , K SankaraRao,PHI Pvt. Ltd .
2. Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd.
3. Mathematical Methods, G. Shanker Rao, K. Keshava Reddy, I.K. International Publishing House, Pvt. Ltd.

Recommended Reference Books:

1. .An Introduction to Computational Physics, Tao Pang, Cambridge University Press
2. Numerical methods for scientific and Engineering computation M.K Jain,S.R.KIyengar, R.K. Jain, New Age International Publishers
3. Computer Oriented Numerical Methods, V. Rajaraman, PHI, 2004.
4. Numerical Methods, E. Balagurusami, Tata McGraw Hill, 2009.
5. Numerical Mathematical Analysis, J.B. Scarborough, 4PthP Edn, 1958
6. Explorations in Monte Carlo Methods Ronald W Shonkwiler and Franklin Mendivil , Springer

PH010303: ATOMIC AND MOLECULAR PHYSICS

Total Credits: 4

Total Hours: 72

Objective of the course**:** This course isintented to develop the basic philosophy of spectroscopy. Its aims to equip the student with the understanding of (1)atomic structure and spectra of typical one- electron and two-electron systems. (2)the theory of microwave and infra-red spectroscopies as well as the electronic spectroscopy of molecules;(3)the basics of Raman spectroscopy and the nonlinear Raman effects; (4)the spin resonance spectroscopies such as NMR and ESR. This course also introduces the student to the ideas of Mossbauer spectroscopy .

UNIT 1

Atomic Spectra (18 Hrs)

1.1 The quantum mechanical treatment of hydrogen atom- quantum numbers n, l and m_l.; spectra of alkali metal vapours 1.2 Derivation of spin-orbit interaction energy in hydrogen-like atoms; extension to penetrating orbits; fine structure in sodium atom 1.3 Normal Zeeman effect; Anomalous Zeeman effect- magnetic moment of the atom and g factor; spectral frequencies; Lande g-formula. 1.4 Paschen–Back effect – splitting of sodium D-lines ; Stark effect – quadratic Stark effect in potassium doublet. 1.5 L S coupling scheme -spectroscopic terms arising from two valence electrons; terms arising from two equivalent s-electrons; derivation of interaction energy - combination of s and p electrons; Hund's rule, Lande interval rule. 1.6 The jj coupling scheme in two electron systems -derivation of interaction energy- combination of s and p electrons ;Hyperfine structure .(qualitative ideas only).

UNIT II

Microwave and Infra Red Spectroscopy (18 Hrs)

2.1 Width of spectral lines-natural width, collision broadening, Doppler broadening. Classification of molecules- linear, symmetric top, asymmetric top and spherical top molecules. 2.2 Rotational spectra of rigid diatomic molecules; effect of isotopic substitution; intensity of spectral lines; energy levels and spectrum of non–rigid rotor

2.3 Information derived from rotational spectra(molecular structure, dipole moment , atomic mass and nuclear quadrupole moment).2.4Vibrational energy of a diatomic molecule- simple harmonic oscillator –energy levels; diatomic molecule as anharmonic oscillator- energy levels; infrared selection rules; spectrum of a vibrating diatomic molecule. 2.5 Diatomic vibrating rotator –P and R branches; break down of Born-Oppenheimer approximation. 2.6 Vibrations of polyatomic molecules – fundamental vibrations and their symmetry; overtone and combination frequencies; Analysis by IR techniques- skeletal vibrations and group frequencies.

UNIT III

Raman Spectroscopy and Electronic Spectroscopy. (18 Hrs)

3.1Quantum theory of Raman effect**;** classical theory-molecular polarizability ;Pure rotational Raman spectra of linear molecules 3.2 Raman activity of vibrations; rule of mutual exclusion; vibrational Raman spectra ;rotational fine structure 3.3 Structure determination from Raman and IR spectroscopy. 3.4 Non- linear Raman effects - hyper Raman effect - classical treatment; stimulated Raman effect - CARS, PARS - inverse Raman effect. 3.5 Electronic spectra of diatomic molecules –Born-Oppenheimer approximation, vibrational coarse structure-progressions and sequences ; intensity of spectral lines- Franck – Condon principle 3.6 Dissociation energy and dissociation products; Rotational fine structure of electronic-vibrational transition ; Fortrat parabola; Predissociation.

UNIT IV

Spin Resonance Spectroscopy (18 Hrs)

4.1 Nuclear Magnetic Resonance (NMR)-resonance condition ; relaxation processes - Bloch equations 4.2 Chemical shift ; indirect spin–spin interaction4.3 CW NMR spectrometer; Magnetic Resonance Imaging.4.4 Electron Spin Resonance(ESR)-Principle of ESR; thermal equilibrium and relaxation; ESR spectrometer; characteristics of the g-factor. 4.5 Total Hamiltonian for an electron; Hyperfine Structure- ESR spectrum of hydrogen atom. 4.6 Mossbauer effect - recoilless emission and absorption; Experimental techniques in Mossbauer spectroscopy 4.7 Isomer shift; quadrupole interaction ; magnetic hyperfine interaction.

Recommended Text Books:

1. Spectroscopy, B.P. Straughan& S. Walker, Vol. 1, John Wiley &Sons
2. Introduction of Atomic Spectra, H.E. White, Mc Graw Hill.
3. Fundamentals of molecular spectroscopy, C.N. Banwell and E M McCash, TataMcGraw Hill Education Private Limited.
4. Molecular structure and spectroscopy, G. Aruldhas, PHI LearningPvt. Ltd.

Recommended References:

1. Spectroscopy (Vol. 2 & 3), B.P. Straughan& S. Walker, Science
2. paperbacks 1976
3. Raman Spectroscopy, D.A. Long, Mc Graw Hill international, 1977
4. Introduction to Molecular Spectroscopy, G.M. Barrow, Mc Graw Hill
5. Introduction to Spectroscopy, D L Pavia, G M Lampman and G S Kriz, Thomson Learning Inc.
6. Modern Spectroscopy, J M Hollas, John Wiley .
7. Elements of Spectroscopy, Gupta, Kumar & Sharma, PragathiPrakshan.
8. https:// teaching.shu.ac.uk/hwb/chemistry/tutorials/molspec/nmr1.htm
9. https://ntpel.ac.in/courses/15101003/downloads/modu21/lecture23.pdf
10. https://www.ias.ac.in/article/fulltext/reso/009/0034-0049
11. https://ntpel.ac.in/courses/122101001/downloads/modu21/lec-15.pdf
12. https://www.youtube.com/watch?v=Q2Fo5BARe Go

SEMESTER IV

PH010401 NUCLEAR AND PARTICLE PHYSICS

Total Credits: 4

Total Hours: 90

Weightage:

Objective of the course:

This course aims to provide the student to build up the fundamentals of nuclear and particle physics. After undergoing this course, the student will have a knowledge about (1) the basic properties of the nucleus and the nuclear forces. (2) Major models of the nucleus and the theory behind the nuclear decay process; (3) the physics of nuclear reactions (4)the interaction between elementary particles and the conservation laws in particle physics. This course intents to impart some idea about nuclear astrophysics and the practical applications of nuclear physics.

Unit I

Nuclear Properties and Force between Nucleons (18 Hrs)

1.1 The nuclear radius- distribution of nuclear charge (isotope shift, muonic shift, mirror nuclei); distribution of nuclear matter. Mass and abundance of nuclides, nuclear binding energy.

1.2 Nuclear angular momentum and parity ; Nuclear electromagnetic moments-quadrupole moment. 1.3 The deuteron-binding energy, spin, parity, magnetic moment and electric quadrupole moment. 1.4 Nucleon-nucleon scattering; proton-proton and neutron-nuetron interactions 1.5 Properties of nuclear forces 1.6 Exchange force model.

Unit II

Nuclear Models and Nuclear Decay (18 Hrs)

2.1 Liquid drop model, Bethe–Weizacker formula, Applications of semi- emperical binding energy formula. 2.2 Shell Model-Shell model potential, Spin-orbit potential, Magnetic dipole moments, Electric quadrupole moments, Valence Nucleons .2.3 Collective structure- Nuclear vibrations, Nuclear rotations.

2.4 Beta decay- energy release in beta decay ; Fermi theory of beta decay 2.5 Angular momentum and parity selection rules- allowed and forbidden transitions. Comparative half lives and forbidden decays; non-conservation of parity in beta decay 2.6 Gamma decay- angular momentum and parity selection rules ; internal conversion.

Unit III Nuclear Reactions (18Hrs)

3.1Types of reactions and conservation laws, energetics of nuclear reactions, isospin. 3.2 Reaction cross sections, Coulomb scattering- Rutherford formula, nuclear scattering. 3.3 Scattering and reaction cross sections in terms of partial wave amplitudes. 3.4 Compound-nucleus reactions; Direct reactions. 3.5 Resonance Reactions.

Unit IV

Particle Physics (18 Hrs)

4.1 Yukawa's hypothesis; properties of pi mesons- electric charge, isospin, mass, spin and parity. 4.2 Decay modes and production of pi-mesons 4.3 Types of interactions between elementary particles, Hadrons and leptons .4.4 Symmetries and conservation laws, C P and CPT invariance, applications of symmetry arguments to particle reactions, parity non-conservation in weak interactions.4.5 Quark model, confined quarks, coloured quarks and gluons, experimental evidences for quark model, quark-gluon interaction, quark dynamics.4.6 Grand unified theories, standard model of particle physics.

Unit V: Nuclear Astrophysics and Practical Applications of Nuclear Physics(18 Hrs.)

5.1 Particle and nuclear interactions in the early universe, primordial nucleosynthesis 5.2 Stellar nucleosynthesis (for both $A<60$ and $A>60$) 5.3 Higg's boson and the LHC experiments; detection of gravitational waves and LIGO (qualitative ideas only)

5.4 Rutherford Backscattering spectroscopy and applications 5.5 Computerized Axial Tomography (CAT) 5.6 Positron Emission Tomography (PET)

Recommended Text Books:

1. Introductory Nuclear Physics, K. S. Krane JohnWiley
2. Nuclear Physics, S.N. Ghoshal, S. Chand & Company.
3. Nuclear Physics: Problem-based Approach Including MATLAB, Hari M Agarwal, PHI Learning Private Limited, Delhi .

Recommended References:

1. Problems and Solutions in Atomic, Nuclear and Particle Physics: Yung-Kuo Lim, World Scientific.
2. Nuclear Physics, S.N. Ghoshal, S. Chand & Company.
3. Introduction to Nuclear and Particle Physics : V M Mittal , R C Verma, S C Gupta (Prentice Hall India .

4. Concepts of Nuclear Physics: B L Cohen, Tata McGrawHill
5. Nuclear Physics: An Introduction – S B Patel, New Age International.
6. Nuclear Physics: R R Roy and B P Nigam, New Age International.
7. Nuclear Physics: R Prasad, Pearson.
8. Atomic Nucleus: R D Evans, Mc GrawHill, New York.
9. Nuclear Physics: I Kaplan, Narosa, New Delhi (2/e)
10. Nuclear and Particle Physics, B R Martin, John Wiley & Sons, New York, 2006.
11. Introduction to Elementary Particles : David Griffith, Wlley-VCH.
12. https://nptel.ac.in/ course/115104043
13. https://www.ias.ac.in/article/fulltext/reso/022/03/0245-0255
14. https://www.ias.ac.in/article/fulltext/reso/017/10/0956-0973
15. https://atlas.cern/updates/atlas-feature/higgs-boson

PH010402 COMPUTATIONAL PHYSICS PRACTICALS

Note

- Develop algorithm / Flowchart for all experiments
- Codes can be developed in any package / programming language. Candidate should be trained to explain parts of the codes used.
- Plotting can be done in any plotting package and can be separate from the programming package / environment.
- Verify numerical results with analytical results wherever possible.
- Repeat experiments for various initial values / functions / step-sizes.
- Training may be given to use methods discussed below to solve real physics problems.

Introduction to computational facility in the Centre

Introduction to the IDE used in the center and commands for execution of a program. Inputting data and variables, outputting results on a console. Achieving arithmetic operations and use of data and variables in the software used at the Centre .Usage of decisions and loops. Creating an array and using array operations. Method of declaring functions and function calling. Writing data to a file and reading data from a file. Getting a graph from a data available using plotting software available with the Centre.

1. Find the root of the given non-linear equations by the bisection method

2. Find the root of the given non-linear equations by the Newton-Raphson method

3. A thermistor gives following set of values. Calculate the temperature corresponding to the given resistance using Lagrange interpolation.

Temperature	1101.0 K	911.3 K	636.0 K	451.1 K	273 K
Resistance	25.113 Ω	30.131 Ω	40.120 Ω	50.128 Ω	?

(This is only a sample data. Students should be capable to interpolate any set of data)

4. Newton's forward interpolation / backward interpolation.

5. Using appropriate technique and the given "Table", Calculate the pressure at the temperature asked.

<u>Steam Table</u>

Temperature in C	140	150	160	170	180
Pressure kgf/cc	3.685	4.854	6.302	8.076	10.22

Temperature: 1750 C (This is only a sample data. Students should be capable to handle another set of data from any other physical phenomena)

6. Value of some trigonometric function [say f(θ) = tan (θ)] for θ=15,30,45,60,75 are given to you. Using appropriate interpolation technique calculate value of f(θ) for a given value.
7. Numerical integration by the trapezoidal rule.
8. Using the trapezoidal rule, calculate the inner surface area of a parabolic reflecting mirror. (length of semi major axis , semi minor axis and height are to be given)
9. Numerical integration by the Simpson rule (both 1/3 and 3/8 rule).
10. Fit a straight line using method of least square to a set of given data without using any built in function of curve fitting. Compare your result with any built in curve fitting technique.
11. Find out the normal equations and hence fit a parabola using method of least square to a set of given data without using any built in function of curve fitting. Compare your result with any built in curve fitting technique.

12. Fit a exponential curve to the given set of data using method of least square with out using any built in curve fitting technique. Compare your result with any built in curve fitting technique.
13. Study the given function as a sum of infinite series. Compare your value with the available standard value.
14. Numerical solution of ordinary first-order differential equations using the Euler methods or the fourth order Runge-Kutta method.
15. Using technique of Monte Carlo method obtain the value of π correct to two decimal places .
16. Using Monte Carlo technique calculate the value of the given integral. Compare your result with result obtained by analytical method.
17. Write a program to solve the given system of linear equations by the Gauss elimination method.
18. Find out inverse of a given matrix by using Gauss-Jordan method.
19. Numerical solution of second-order differential equations using the fourth order Runge-Kutta method.
20. Fast Fourier Transform of a given signal.
21. Solution of Heat equation / Diffusion equation using Finite Difference Method.
22. A Duffing oscillator is given by $\ddot{x} + \delta \dot{x} + \beta x + \alpha^{3} = \gamma \cos \omega t$ where δ is damping constant>0. Write a program to study periodic and aperiodic behavior
23. Study of path of a Projectile in motion with and with out air drag and compare the values .
24. A study of Variation of magnetic field B(T) with critical temperature in superconductivity
25. Generation of output waveform of a Half wave / full wave rectifier.
26. Charging /discharging of a capacitor through an inductor and resistor
27. Variation in phase relation between applied voltage and current of a series L.C.R circuit
28. Phase plot of a pendulum (driven and damped pendulum)
29. Study variation of intensity along a screen due to the interference from Young's double slit experiment. Also study the variation of intensity with variation of distance of the screen from the slit.

30. Study variation of intensity along a screen due to the diffraction due to a grating .Also study the variation of intensity with variation of distance of the screen from the grating.
31. A particle obeying F-D statistics is constrained to be in 0 to 2eV at 300K. Calculate Fermi energy of this particle assuming kT =.025eV at 300K
32. Solve the following differential equation and study periodic and aperiodic behavior.

$$\frac{dy}{dx} = \sigma(y - x), \qquad \frac{dy}{dx} = x(\rho - z) - y, \qquad \frac{dy}{dx} = xy - \beta z$$

33. Study the difference equation $X_{n+1} = mX_n (1 - X_n)$ and obtain periodic and aperiodic behavior.
34. Generate a standing wave pattern and study change in pattern by changing its various parameters.

Reference books

1. Computational Physics: An Introduction, R.C. Verma, P.K. Ahluwalia & K.C. Sharma, New Age India, Pvt. Ltd ,2014.
2. An Introduction To Computational Physics, 2nd Edn,Tao Pang Cambridge University Press, 2010
3. Numerical Recipes: The Art of Scientific Computing 3rd Edn, William H. Press Cambridge University Press, 2007.

ELECTIVES

BUNCH-A: ELECTRONICS

PH800301: DIGITAL SIGNAL PROCESSING

Total Credits: 3

Total Hours: 54

Objective of the Course: To study about **discrete** time systems and to learn about FFT algorithms. To study the design techniques for FIR and IIR digital filters.

UNIT I

Discrete time signals and Linear systems (16 Hours)

1.1 Examples of Signals -1.2 Classification of signals -1.3 System-1.4 Examples of discrete time 1.5System models 1.5-Signal processing-1.6 Advantages ,Limitations and applications of DSP- 1.7 Elementary continuous time signals-1.8 Representation of discrete time signals-1.9 Elementary discrete time signals-1.10 Classification of discrete time signals-1.11 Operation on signals-1.12 Sampling and Aliasing -1.13 Discrete time system-Classifications-1.14 Representation of an arbitrary sequence-1.15 Impulse response and convolution sum-properties-Causality-1.15 FIR,IIR, stable and unstable systems-1.16Correlation of two sequences.

UNITII

DSP Techniques (10 Hrs)

2.1Frequency analysis of Discrete Time signals – 2.2 Discrete frequency spectrum and frequency range -2.3 Development of DFT from DTFT – 2.4 Definition of Discrete Fourier transform-2.5 Frequency spectrum using DFT- 2.6 Properties of Discrete Fourier transform-2.7Relationship of the DFT to other transforms-Properties-2.8 Fast Fourier Transform (FFT) – 2.9Decimation in time algorithm –Radix- 2 FFT -8 point DFT using Radix -2 DIT FFT

UNIT III

Z Transform (12 Hrs)

3.1 Z-Transform & ROC -properties -3.2 Z transform of finite duration ,infinite duration and two sided sequence – 3.3 System function – 3.4 Poles and Zeros-

Stability criterion 3.5 (Problems based on determination of Z trasform,ROC and Properties are expected)

UNIT IV

Digital Filters (16 Hrs)

4.1 IIR filters-frequency selective filters-4.2 Design of digital filters from Analog filters-4.3 Analog low pass filter design-4.4 Design of IIR filters from Analog filters-4.5Approximation of derivatives -4.6 Design of IIR filter using impulse invariance Technique-4.7 Bilinear transformation-4.8Direct form I structure of IIR systems-4.9Cascade form realization of IIR systems-4.10 Realization of digital filters-4.11 Direct form I realization-4.12 Direct form II realization-4.13 FIR filters-4.14 Linear phase FIR filters-4.15 Design of FIR filter using rectangular window-4.16The Fourier series method of designing FIR filters

Recommended Text Books:

1. Digital Signal Processing, Fourth edition P. Ramesh Babu, Scitech
2. Digital signal Processing – A NagoorKani, Tata Mc Grow Hill
3. Digital Signal Processing: Theory, Analysis and Digital-Filter Design, B. Somanathan Nair, PHI (2004)
4. Digital Signal Processing, Alan V. Oppenheim & R.W. Schafer, PHI
5. Digital Signal Processing -A practical Guide for scientists and Engineers- Steven W Smith
6. Digital signal processing -Hand book – Vijay K Madisetty & Douglas B Williams

Recommended References:

1. Computer applications in physics, Suresh Chandra, Alpha Science International (2006)
2. Digital Signal Processing, S. Salivahanan, A. Vallavaraj, C.Gnanapriya, TMH
3. Signals and Systems, Allan V. Oppenheim, Alan S. Willsky, S.H.Nawab, PHI
4. Digital Signal Processing, John G. Proakis, Dimitris G. Manolakis, PHI
5. Digital signal processing, Sanjay Sharma, S.K. Kataria& Sons, 2010
6. Mathematical Methods for Physicists,G.B.Arfken&H.J.Weber.Elsavier, Academic Press
7. Digital signal; processing – V K Khanna S.Chand
8. Digital Signal Processing and Applications - Dag Stranneby&William Walker

PH800402: MICROELECTRONICS AND SEMICONDUCTOR DEVICES

Credits: 3

Number of hours: 90

Objective:The objective of the course is to expose to the students to the architecture and instruction set of basic microprocessors. This course also covers fundamentals of semiconductor devices and their processing steps in detail. The student will be able to use the knowledge of semiconductor fabrication processes to work in industry in the area of semiconductor devices.

UNIT I

Introduction to microprocessors (20Hrs)

1.1Microprocessor organization- General organization of a microprocessor based microcomputer system 1.2 Memory organization – main memory array –memory management, cache memory, virtual memory 1.3 Input/output operation - Standard I/O – memory mapped I/O- interrupt driven I/O –DMA1.4 8085 Microprocessor – Architecture1.5 8085 addressing modes, instruction set, Pin out diagram,1.6 Simple programming concepts.

UNIT II

8086 Microprocessor (16Hrs)

2.1 The Intel 8086- Architecture - MN/MX modes –Pin diagram 2.2 8086 addressing modes 2.3 8086 instruction set- instruction format- assembler directives and operators 2.4.Programming with 8086- Familiarisation with Debug utility2.5. Interfacing memory and I/O ports.

UNIT III

Microcontrollers (19 Hrs)

3.1 Introduction to microcontrollers and embedded systems 3.2 Comparison of microprocessors and microcontrollers 3.3 The 8051 architecture - Register set of 8051 – important operational features 3.4 I/O pins of 8051, ports and circuits - external memory - counters and timers – interrupts 3.5 Instruction set of 8051 - Basic programming concepts 3.6 Applications of microcontrollers - (basic ideas) – Embedded systems(basic ideas)

UNIT IV

Metal-semiconductor and semiconductor hetero-junctions(17Hrs)

4.1 Metal-semiconductor - Schottky barrier diode - qualitative characteristics – ideal junction properties- 4.2 Current voltage relationship, Comparison with junction diode 4.3 Metal semiconductor ohmic contact 4.4 Idealnon rectifying barriers – tunneling barrier – specific contact resistances 4.5 Semiconductor hetero-junctions – hetero-junction materials – energy band diagram –Two dimensional electron gas 4.6equilibrium electrostatics – current voltage characteristics.

UNIT V

Integrated Circuit Fabrication and Characteristics (18 Hrs)

5.1 Integrated circuit technology – basic monolithic IC – epitaxial growth –marking and etching 5.2 diffusion of impurities – transistor for monolithic circuit 5.3.Monolithic diodes – integrated resisters, capacitors and inductors5.4 monolithic circuit layout - additional isolation methods -MSI, LSI, VLSI– the metal semiconductor contact.

Recommended Text books:

1. Microprocessor Architecture Programming and Applications with 8085, R.S. Gaonkar – Penram int. Pub. Mumbai
2. Fundamentals of Microprocessors and microcomputers- B. Ram (DhanpatRaiPub.)
3. Microprocessors and Microcomputer based system design, H. Rafiquizzaman, Universal Book stall, New Delhi
4. The 8051 microcontroller, Architecture Programming and Applications, Kenneth J Ayala- Penram Int. Pub. Mumbai
5. Semiconductor Physics and Devices, Donald A. Neamen, McGraw Hill
6. Integrated Electronics-Analogue and Digital Circuits and Systems, J Millmann and C C Halkias, TMGH

Recommended References:

1. 0000 to 8085 Introduction to Microprocessors for Engineers and Scientists.- P.K. Gosh & P.R. Sridhar, PHI
2. Advanced microprocessors and peripherals, A.K. Ray & K.M. Burchandi –TMH

3. Microprocessor and microcontroller, R. Theagarajan- SCITECH Publications India Pvt. Ltd.
4. Microprocessor and Peripherals, S.P. Chowdhury& S. Chowdhury- SCITECH Publications.
5. Operating system Principles, Abraham Silberschatz& Peter Baer Galvin & Greg Gagne, John Wiley
6. Solid state electronic devices, Streetman and Banerjee, PHI (2010).
7. Physics of Semiconductor Devices, Michael Shur, PHI (2002).
8. Introduction to Semiconductor materials and Devices, M.S. Tyagi, John Wiley and Sons (2000)

PH800403: COMMUNICATION SYSTEMS

Total Credits: 3

Total Hours: 90

Objective of the Course:To understand the basic concepts of different communication systems.

UNIT 1

Digital Communication(18 hrs)

1.1 Pulse Communication -Introduction - Pulse modulation :– PAM - PWM – PPM- PCM 1.2 PCM:– Sampling theorem- Quantisation -Noise Generation and demodulation of PCM- Companding - DPCM- ADPCM-Delta modulation 1.3 Information theory-Coding-Noise-Data Communication – Digital codes – Error detection and correction 1.4 Data sets and interconnection requirements-Modem classification and interfacings1.5 Multiplexing techniques -Frequency division multiplex -Time division multiplex1.6 Digital transmission techniques:-ASK- FSK-PSK-QPSK.

UNIT II

Mobile communication(20 hrs)

2.1Introduction to Wireless Communication Systems-Mobile Radio System Around the World- Examples of wireless communication systems: - Paging system-Cordless Telephone System- Cellular Telephone System—How a Cellular Telephone Call is

Made- Comparison of Common Mobile Radio Systems- Trends in Cellular and Personal Communications2.2 Wireless communication systems—2G-3G - 4G

2.3 The Cellular Concept-Frequency Reuse-Channel Assignment Strategies-Handoff Strategies:—Prioritizing handoffs and practical handoff consideration-Interference and System Capacity-Improving Coverage and Capacity in Cellular Systems:—Cell splitting- Sectoring-Microcell zone concept 2.4 Basic idea of Path Loss and Multipath Fading 2.5Multiple Access Techniques –Introduction-FDMA-TDMA-SSMA:- FHMA-CDMA-Hybrid Spread Spectrum Techniques-SDMA 2.6 GSM.

UNIT III

Satellite Communication (16 hrs)

3.1 Satellite Communication Fundamentals-Satellite Orbits-Satellite Positioning-Frequency Allocations-Polarization-Antennas—gain-beam width-Multiple Access Techniques 3.2 Geostationary Satellite communication-Satellite parameters 3.3VSAT (Basic Idea) 3.4Geostationary Satellite Path/Link Budget 3.5 Satellite TV Systems-Satellite TV broadcasting 3.6GPS.

UNIT IV

Fiber Optics Communication(20 hrs)

4.1 Introduction 4.2 Ray theory transmission-Total Internal Reflection-Acceptance Angle-Numerical aperture-Skew rays 4.3 Electromagnetic mode theory for optical propagation-Electromagnetic waves-Modes in a planar guide-Phase an group velocity 4.4 Fiber Classification-cylindrical fiber-Step Index- Graded Index-Single mode fiber:- Cut off wave length-Group delay -Photonic crystal fibers:-Index guided micro structures-Photonic band gapfibers 4.5 Dispersion:- chromatic-intermodal-Non linear effects 4.6 Optical fiber connection-Fiber Splices:-Fusion splices- Mechanical splices-Multiple splices-Fiber connectors:- Cylindrical ferrule connectors, Duplex and multiple-fiber connectors-Fiber couplers(basic idea).

UNIT V

Radar Systems (16 hrs)

5.1 Basic Principles –Fundamentals:- Basic radar Systems-Development of Radar-Radar Performance Factors:—Radar range equation-factors influencing maximum range-Effects of noise- Target properties 5.2 Pulsed Systems-Block diagram and description-Antennas and Scanning:-Antennas Scanning- Antenna tracking-Display Methods5.3 Pulsed radar systems-Moving Target Indication:- Doppler Effect-Fundamentals of MTI-Delay Line- Blind speeds-Radar Beacons5.4Other radar systems-CW Doppler Radar-Frequency Modulated CW Radar-Phased ArrayRadars-Planar Array Radars.

Recommended Text Books:

1. Electronic Communication Systems by Kennedy/Davis, Mc Graw Hill Publication, 4th edition,(Module-1 and 5).
2. Wireless Communication Principles and Practice by Theodore S Rappaport, Person Publication, 2nd Edition, (Module-2).
3. Telecommunication Transmission Systems by Robert G Winch, McGrawHill Publication,2nd edition,(Module-3).
4. Optical fiber communications-Principles and Practice John M Senior, Pearson publications, 3rdedition, (Module-4).

Recommended References:

1. Optical Fiber Communications by Gerd Keiser(Module-2).
2. Satellite Communications by Dennis Roddy, Mc Graw Hill Publication,3rd edition.
2. Introductions to RADAR Systems by Skolnik, McGraw Hill, 3rd edition
3. Satellite communication by Dr.D.C Agarwal.
4. Electronics Communication Systems by Wayne Thomas, Pearson Publication, 5 th Edition.

PH800302: ADVANCED PRACTICALS IN ELECTRONICS

Total credit: 5

Total hours: 180

(Minimum of 12 Experiments should be done choosing at least 2 experiments from each group)

[A] Microprocessors and Micro Controllers (use a PC or 8086-µp kit)

1. Sorting of numbers in ascending/descending order.
2. Find the largest and smallest of numbers in array of memory.

2. Conversion of Hexadecimal number to ASCII and ASCII to Hexadecimal number.
3. Multi channel analog voltage measurements using AC card.
4. Generation of square wave of different periods using a microcontroller.
5. Measurement of frequency, current and voltage using microprocessors.

[B] Communication Electronics

6. Generation PAM and PWM
7. Frequency modulation and demodulation using IC –CD4046.
8. Multiplexer and demultiplexer using digital IC 7432.
9. Radiation characteristics of a horn antenna.
10. Measurement of characteristic impedance and transmission line parameters of a coaxial cable.

[C] Electronic Instrumentation

11. DC and AC milli-voltmeter construction and calibration.
12. Amplified DC voltmeter using FET.
13. Instrumentation amplifier using a transducer.
14. Generation of BH curve and diode characteristics on CRO.
15. Voltage to frequency and frequency to voltage conversion.
16. Construction of digital frequency meter.
17. Characterization of PLL and frequency multiplier and FM detector.

[D] Optoelectronics

18. Characteristic of a photo diode - Determination of the relevant parameters.
19. Beam Profile of laser, spot size and divergence.
20. Temperature co-efficient of resistance of copper.
21. Data transmission and reception through optical fiber link.

References

1. Sedra, Adel S., Smith, Kenneth C., “Microelectronics Circuits”, 5th Edition, Oxford University Press,NewYork.
2. Smith, Kenneth C., “Laboratory Explorations for Microelectronic Circuits”, 4th Edition, Oxford University Press,New York

3. Mims, Forrest, M., “Engineer’s Mini-Notebook, Op-Amp Circuits”, 2nd Edition, Siliconcepts
4. Microelectronics Circuit Analysis and Design, D. A. Neamen, McGraw Hill, 4th Edition
5. Electronics Lab Manual Volume 1,2,3 K. A. Navas, Rajath Publishers, Kochi Electronics lab Manuel, T D Kuryachan, S. Shyam Mohan, Ayodhya Publication.
6. Basic Electronics: A text. Zbar, Paul.B Lab Manual M C Graw Hill Tata
7. Edminister, Joseph, Electric Design, M C Graw Hill Tata

BUNCH-B MATERIAL SCIENCE

PH810301: SOLID STATE PHYSICS FOR MATERIALS

Total Credits: 3

Total Hours: 54

UNIT 1

Crystal defects [18h]

1.1 Crystal Imperfection- point imperfections- vacancy, Frenkel and Schottky imperfections,

1.2 dislocations- Edge, screw, Burger’s vector critical resolved shear stress,

1.3 dislocation motion , dislocation reaction, dislocation energy, slip;

1.4 surface and volume imperfections – stacking faults; Fracture, twinning [Ref. 5]

1.5 Voids in close packing- size, coordination and significance,

1.6 Pauling’s rule and applications; Allotropy, polymorphism [Ref. 4]; polytypism

UNIT II

(A) Atomic Diffusion [6h]

2.1 Fick’s laws, solution and applications;

2.2 Kirkendall effect, Atomic model of diffusion and other diffusion processes and mechanisms

(B) Crystal binding: [12h]

2.3 Crystals of inert gas, Van der Waals- London interaction, Repulsive interaction, equilibrium lattice constants, cohesive energy, 2.4 Ionic crystals- Madelung energy, Madelung constant,

2.5 Covalent crystals, metals, hydrogen bond; Born-Haber cycle

UNIT III

(A) Phase diagrams: [6h]

3.1 Phase diagram rules, unary and binary phase diagrams,

3.2 microstructural changes during cooling, applications

(B) Excitations in solids [12h]

3.3 Plasma optics, plasmons;

3.4 Polaritons, LST relation;

3.5 electron-phonon interaction: polarons;

3.6 Kramers Kronig Relations; excitons- Frenkel and Wannier excitons, electron hole drops;

3.7 Magnons- spin wave quantization and thermal excitation of magnons.

Recommended textbooks:

1. Materials Science and Engineering- V Raghavan-PHI
2. Introduction to solid state physics- C Kittel- Wiley India
3. Solid State Physics- Wahab- Narosa

Recommended References:

1. Lectures on Solid State Physics- Georg Busch & Horst Schade; Pergamon Press
2. Callister’s Materials Science and Engineering- Wiley India
3. Elementary Solid State Physics: M Ali Omar- Pearson
4. Solid State Physics- S O Pillai- New Age;
5. Introduction to solids- Azaroff-TMH;
6. Solid State Physics- Adrianus J Dekker- Macmillan

PH810402: SCIENCE OF ADVANCED MATERIALS

Total Credits: 3

Total Hours: 90

UNIT 1:
Ceramics, polymers and composites [25h]

(A) Ceramics:

1.1 Types, properties and applications of ceramics: Glass, clay, refractories, abrasives, cements, advanced ceramics, piezoelectric ceramics,

1.2 mechanical and glass properties, heat treatment of glasses, Perovskite structure, Classification of ferroelectric materials, dielectric breakdown [Ref 3].

(B) Polymers:

1.3 polymer structure and configurations, thermosetting and thermoplastic , copolymers, conducting polymers, mechanical behaviour of polymers,

1.4 Mechanisms of deformation and strengthening, crystallization, melting and glass transition; polymer types-plastics, elastomers, fibers, polymerisation and applications.

(C) Composite materials:

1.5 particle reinforced composites, fiber –reinforced composites, structural composites, Semimetals

UNIT II
(A) Optical properties of materials [10h]

2.1 Absorption processes, photoconductivity, photovoltaic effect, colour centers-types and generation

2.2 Luminescence – photoluminescence, cathodoluminescence, electroluminescence, injection luminescence, radiative recombinationGaussian Beam- Amplitude, properties, quality; [Ref 1]Optical coherence- temporal, spatial [Ref 2]

(B) Lasers [10h]:

1.3 Absorption of radiation, threshold conditions, lineshape function, population inversion and pumping threshold conditions, laser modes,

1.4 semiconductor lasers, hetero junction lasers. Methods of pulsing lasers – Q switching and mode locking

UNIT III

Photonic materials and Applied Photonics [20h]

3.1 **LEDs [5h]:** Principles, structure, materials and characteristics, heterojunction LED, SLED and ELED

3.2 **Solar cells [5 h]-** principles, characteristics, PERL, heterojunction, cascaded, and schottky barrier cells, material and design considerations [Ref 5]

3.3 Basic concepts and features of Photonic crystals, [Ref 6] Liquid crystals, [Ref 7] optics of metamaterials, [Ref 1] Amorphous semiconductors. [Ref 7] detector arrays-CCDs

3.4 Electro-optic effect, magneto-optic effect, acousto-optic effect.

UNIT IV

Superconductors, Thin films and crystal growth [25 h]

(A) Superconductors: [12 h]

4.1 Thermodynamics and electrodynamics,

4.2 BCS theory, flux quantization, type I &II superconductors,

4.3 single particle tunnelling, Josephson tunnelling, high temperature superconductors

(B) **Thin films: [7h]**

4.4 Nature- deposition technology-Resistance heating, Cathodic sputtering, interferometric film thickness measurement, Applications: Antireflection coating, solar cells and sensors.

(C) **Crystal growth:[6h]**

4.5 Mechanism of crystal growth, nucleation, classification of crystal growth methods, growth from melt-Czochralski, Bridgeman, Floatzone techniques, growth from solution - gel growth. [Ref 8, 11]

Recommended Text Books:

1. Solid State Physics- Wahab- Narosa;
2. Optoelectronics- Wilson & Hawkes- Pearson 2018;
3. Optoelectronics- Wilson & Hawkes- Pearson 2018;
4. Optoelectronics and Photonics: Principles and Practices- S O Kasap- Pearson
5. Introduction to solid state physics- C Kittel- Wiley India
6. Thin film fundamentals: A Goswami- New Age ;
7. Semiconductor Physics and devices, S.S. Islam, Oxford University press.

Recommended References:

1. Fundamentals of Photonics- Saleh and Teich- wiley India;
2. Lasers and Nonlinear Optics: B B Laud; New Age,
3. Solid State Physics- S O Pillai- New Age;
4. Solid State Physics- Wahab- Narosa;
5. Semiconductor Optoelectronic Devices: Pallab Bhattacharya- Pearson
6. Introduction to nanotechnology: Charles P Poole, Frank J Owens-wiley india
7. Elementary Solid State Physics: M Ali Omar- Pearson
8. Crystal growth: processes and methods- P.S. Raghavan and P. Ramasamy, KRU publications
9. Materials Science and Engineering- V Raghavan-PHI.
10. Essentials of Crystallography- M A Wahab- Narosa
11. Semiconductor Devices: Physics and Technology- S M Sze- Wiley India
12. Fiber optics and Optolelectronics- R P Khare- Oxford

PH810403: NANOSTRUCTURES AND MATERIALS CHARACTERISATION

Total Credits: 3

Total Hours: 90

UNIT 1

Nanostructures: Synthesis and properties [25 h]

1.1Applications of Schrodinger equation in nanoworld: particle confined in one dimension, quantum leak, penetration of barrier, 1.2 nanostructures for electronics-quantum dots, nanowires, superlattices and heterostructures1.3 Preparation of quantum nanostructures, size and dimensionality effects, single electron tunnelling. Metal nanoclusters, semiconducting nanoparticles, rare gas and molecular clusters. Self assembly and catalysis 1.4 Synthesis routes: bottom up approaches- PVD, CVD, MBE, PLD, wet chemical; 1.5 top down synthesis routes- mechanical alloying, nanolithography.

UNIT II

Nanomaterials and applications [20 h]

2.1Carbon nanostructures: carbon clusters, fullerenes, CNTs- fabrication, properties and applications , 2-D nanostructure- graphene [Ref 6]2.2 Nanostructured materials:

superparamagnetic nanoparticles, GMR, ferrofluids, colossal magnetoresistance, nanostructured thermal devices, superhydrophobic nanostructured surfaces, biomimetics; 2.3 nanomachines and nanodevices- MEMs,NEMs, nanosensors, 2.4 molecular and supramolecular switches, nanocatalysts, properties and applications of nano ZnO and TiO_2, dendrimers, micelles

UNIT III

Optical Absorption and Emission spectroscopy [20 h]

3.1Instruments for absorption photometry – radiation sources, wavelength selection, cells and sampling devices, detectors; Fundamental laws of photometry (Beer Lambert's law), spectrophotometric accuracy, precision, absorptivity, bathochromic and hypsochromic shift, Jablonski diagram 3.2 Principles of Fourier transform optical measurements- advantages of Fourier transform spectrometry, time domain spectrometry, fourier transform of interferograms. 3.3 optical atomic spectra- atomic line widths, effect of temperature;3.4 Principles and applications of Differential, difference and derivative spectroscopy, photoacoustic and thermal lens spectroscopy; General applications of uv absorption spectroscopy 3.5 Theory of fluorescence and phosphorescence spectrophotometry, PL power, total luminescence spectroscopy, fluorescence lifetime measurements, quenching and applications, principle and applications of chemiluminescence, Qualitative ideas of resonance raman spectroscopy, surface enhanced raman spectroscopy,

UNIT IV

Chemical, thermal and X-ray diffraction methods [25 h]

4.1X ray diffraction- production and detection of X-rays and X-ray spectra, Moseley's law, Geometry of an X-ray diffractometer, [Ref 3] 4.2 X-ray photoelectron spectroscopy, X-ray fluorescence, Particle size determination, Debye Scherrer formula, stress measurementAuger recombination, Auger Emission Spectroscopy, 4.3 Working of SEM, TEM, AFM and STM with instrumentation 4.4 **Mass spectrometry**: ionization methods, mass spectrometers and analyzers, correlation of mass spectra with molecular structure. 4.5 **Thermal methods**: thermogravimetry, DTA, DTG, DSC, microthermal analysis; Principles of pH measurement, potentiometry, voltammetry and electrogravimetry

Recommended Text Books: (Unit 1 & 2)

1. Introduction to nanotechnology: Charles P Poole, Frank J Owens-Wiley india
2. Textbook of nanoscience and nanotechnology- B S Murty, P Shankar, Baldev Raj, B B Rath, James Muday- Springer Univ. Press
3. Introduction to nanoscience and nanotechnology- KK Chattopadhyay and A N Banerjee-PHI
4. Introduction to Nanoscience- S M Lindsay, Oxford University Press.

Recommended Text Books: (Unit 3&4)

1. Instrumental methods of analysis- Williard, Merritt, Dean, Settle- CBS
2. Introduction to nanoscience and nanotechnology- KK Chattopadhyay and A N Banerjee-PHI
3. Introduction to Nanoscience- S M Lindsay, Oxford University Press.
4. Principles of Instrumental analysis- Holler, Skoog, Crouch-Cenage

Recommended references:

1. Instrumental methods of chemical analysis-Chatwal, Anand- Himalaya
2. Instrumental methods of chemical analysis- Galen W Ewing-MGH
3. X ray diffraction a practical approach :C Suryanarayana, M Grant Norton; Springer
2. Nanophotonics- Paras N Prasad: Wiley
3. Nanostructures and nanomaterials- G Cao and Y Wang- World Sci.
4. Graphene: Synthesis, Properties and Applications in Transparent electronic devices- P Kumar etal- Reviews in Advanced Sciences and Engineering, vol 2, pp1-21, 2013

PH810302: ADVANCED PRACTICALS IN MATERIAL SCIENCE

Total credit: 5

Total hours: 180

** Minimum number of experiments to be done 12*

***Error analysis of the result is a compulsory part of experimental work*

1. Malu's law- verification
2. Optical activity- specific rotation measurement
3. Stefan's constant- torch bulb filament resistance measurement
4. Absorption coefficient of solution- path length and concentration dependence
5. XRD- Crystal Structure Determination Cubic/Hexagonal
6. XRD-Lattice Parameter Measurements
7. XRD- Phase Diagram Determination
8. XRD-Determination of Crystallite Size and Lattice Strain
9. Zeeman effect- shift of atomic energy levels
10. Laser- measurement of thread angle, pitch and the diameter of a micrometre screw
11. Thin film thickness- Newton's rings/ Michelson interferometer
12. Magneto-optic effect - Determination of Verdet constant
13. Michelson interferometer /Edser Butler method/ Fresnel's biprism- mica sheet thickness
14. Bandgap- semiconductor diode
15. Laser –Young's double slit - interference
16. Refractive index of liquid- Newton's ring /Laser/ Fresnel's biprism
17. Resolving power- lens- Laser
18. Rydberg constant- Hydrogen discharge tube
19. Particle size – corona plate
20. Comparison of thickness of thin sheets by air wedge
21. Band gap and type of optical transition (direct or Indirect using Tauc relation) from absorption spectra
22. Synthesis of metallic (Ag or Au) nanoparticles in aqueous medium and estimation particle size using absorption spectrum

23. Thermal analysis of materials from experimental data
24. Analysis of FTIR spectrum
25. Solar cell- efficiency& Fill factor
26. Laser diffraction- comparison of thickness of wires of different gauges
27. Thermistor –parameters [energy band gap]
28. Temperature sensor- silicon diode and thermocouple
29. Optical fiber- bending loss
30. Fermi energy of copper
31. ESR spectrometer- g factor
32. Verification of laws of geometrical optics- reflection and transmission coefficients, critical angle, refractive index of glass slab/ prism
33. Study of Bravais lattices with the help of models
34. Verification of Fresnel's equations
35. Spring constant-static and dynamic method
36. Coherence length of LED
37. Comparison of resistance variation of a carbon film resistor, metal wire, semiconductor and thermistor with temperature
38. Thermal diffusivity of brass
39. Young's modulus- strain gauge
40. Michelson interferometer- Sodium D lines separation
41. Fresnel's biprism- wavelength of monochromatic light

References:

1. A course of experiments with He-Ne laser- R S Sirohi, Wiley
2. Practical Physics- C L Arora, S Chand
3. X ray diffraction a practical approach :C Suryanarayana, M Grant Norton; Springer
4. Practical Physics: D Chattopadhyay, P C Rakshit; New Central Book Agency
5. Advanced practical physics: Chauhan, Singh; Pragati Prakashan

BUNCH C- INFORMATICS

PH820301: PROGRAMMING IN JAVA AND HTML

Total Credits : 3

Total Hours : 54

Objectives:

To equip the students with concepts of object oriented programming principles and skills in web programming.

UNIT I : (14 Hrs)

Fundamentals of Object Oriented Programming, Overview of Java Language – constants, variables and data types: Integers - Floating point – Characters – Boolean, type conversion and casting, Operators: Arithmetic operators –Bitwise operators, Relational operators – Boolean logical operators – Assignment operators – Conditional operators - expressions

Decision making and branching: simple if, if - else, if - else if, switch - case, Decision making and Looping: for, while, do - while, example programs

UNIT II: (16 Hrs)

Strings, arrays: one dimensional array – multidimensional array, vectors, class: fundamentals – declaring objects – introducing methods – constructors – garbage collection – finalize() method, overloading methods, inheritance: basics – types – use of super keyword – method overriding, interfaces – basics only, packages – introduction – importing packages , access protection, exception handling – introduction – exception types – using try and catch, Multithreaded programming: java thread model – life cycle, Applets – introduction only.

UNIT III: (14 Hrs)

Basic Hypertext elements – HTML, Head, Title, Body tags - paragraphs, formatting of text: headings - formatting tags – pre tag – font tag – anchors – links - lists: unordered list- ordered list – Definition list, tables - <table>, <tr>, <td> tags, cell spacing, cell padding, colspan and rowspan, forms: forms and input tag – text box – radio button – check box – select tag and pull down list – submit and reset.

UNIT IV (10 Hrs)

Introduction to scripting, purpose of scripting, javascript: variables – data types – statements – operators , control structures: conditional statements - loop statements, break and continue, functions, Document methods: write and writeln methods, message boxes: dialog boxes – alert - prompt- and confirm boxes. Events familiarization: OnLoad, OnClick, OnSubmit.

Recommended Text Books:

1. Programming With Java – A Primer, E. Balagurusamy 3rd Edn TMH. Text Book
2. HTML, The Complete Reference, Tata Mc Graw Hill
3. Beginning JavaScrpit, Paul Wilton, Wrox Press Inc. 1st

Recommended Reference Books:

1. JAVA2, The Complete Reference, Herbert Schidlt, 4th Edn. TMH
2. HTML4, 2nd Edn. Rick Darnell, Techmedia
3. Mastering HTML4 – Ray D S and Ray E J - BPB
4. Eloquent Java Script A modern introduction to programming – Marijn Haverbeke
5. Essential Javascript – A javascript Tutorial
6. JavaScript Programmers Reference, Cliff Wootton, Wrox Press Inc.

PH820402: DATA COMMUNICATION AND COMPUTER NETWORKS

Total Credits : 3

Total Hours : 90

Objectives:

To equip the students with concepts of data communication techniques and network principles and security features.

UNIT I (24 Hrs)

Data Communication Terminology: – Channel – Baud – Bandwidth - Frequency. Modes of data transmission : Serial and Parallel - Synchronous, Asynchronous & Isochronous Communications - Analog & Digital Data Transmission - Transmission impairments – Attenuation-Delay Distortion Noise - Concept of Delays. Transmission

Media and its Characteristics: – Magnetic media - Twisted pair-Base band coaxial cable - Broadband Coaxial cable - Optical Fiber - Comparison between optical fiber and copper wire - Wireless transmission – Microwave Transmission - Radio Transmission - Infrared and millimeter waves - Wireless LAN.

UNIT II (18 Hrs)

Multiplexing: FDM – TDM, Switching paradigms: circuit - packet and cell switching – propagation delay – clock synchronization. Network access control: Centralized – decentralized - distributed Overview of satellite communication – Fourier series & transforms and their applications to data communication.

UNIT III (20 Hrs)

Computer Networks: Importance of Networks – Components of Networks - Classification of Networks: Broadcast networks - Switched networks, Switching Techniques, Types of Networks: LAN – MAN – WAN. Networking Models: OSI reference model – TCP/IP reference model, Network Topology: Bus-Star-Ring-Tree-Mesh-Cellular, Network Architecture: Client/Server - Peer-to-Peer.

UNIT IV (28 Hrs)

The Internet: Internet Protocols: Internet Protocol (IP) - Transmission Control Protocol (TCP), Internet Address: Structure of Internet Servers Address - Address Space, Internet Infrastructure, Services on Internet, Domain Name System, SMTP and Electronic mail, Http and World Wide Web, Usenet and News groups-FTP-Telnet(18 Hrs) Network Security: Security requirements and attacks - Cryptography – introduction - Substitution ciphers - Transposition ciphers -Ideas of secret key Algorithms and Public key Algorithms - Digital Signature, E-mail Privacy - Internet Tools – Search Engines-Web browsers (10 Hrs)

Recommended Text Books:

1. Data and Computer communication, William Staling, 7th Edn. PHI
2. Computer Networks, A.S. Tanenbaum, PHI
3. Internet and World Wide Web, Harvey M. Deitel, PHI

PH 8204 03: COMPUTER APPLICATIONS IN PHYSICS

Total Credits : 3

Total Hours : 90

Objectives:

To equip the students with knowledge in MATAB and Python Programming language.

UNIT I (28Hours)

Introduction to MATLAB

Representing numbers in a computer – Machine precision – Introduction to numerical errors – Errors in mathematical approximations – Error propagation – Introduction to MATLAB – Workspace – Creating arrays –Matrix operators – Generating vectors– Infinite loops –Introduction to *M*files– Graphics in MATLAB – Creating 2D graphs –Introduction to Mesh and Surface plots (12 Hrs).

Constructing Real and Complex Variables, Symbolic Math Functions, Derivatives of Expressions with Several Variables, Integration with Complex Parameters, Symbolic Summation, Taylor Series, Finding the Maximum, Minimum and inflexion points, Singular Value Decomposition, Systems of Nonlinear Equations. (16 Hrs).

UNIT II (20 Hours)

MATLAB Toolboxes

Introduction to tool boxes - MATLAB Tools for Fourier Analysis, Short-Time Fourier Analysis, MATLAB tools for Wavelet Analysis, Continuous Wavelet Transform, Scaling, Shifting, ,One-Dimensional Complex Continuous Wavelet Analysis – instrument control toolbox – partial differential equation toolbox – finite element method.

Ordinary Differential Equations, Decay of a Radioactive Sample, Simple Harmonic Oscillator, Basics of Artificial Neural Network and its applications.

UNIT III (18 Hours)

Introduction to Python

Variables and Data Types, Strings, Lists (split, join, copy), Operators and Precedence, I/O operations, Iteration: while and for, Conditional Executions, Functions, Modules and Packages, File Input/output, Dictionaries. Numpy Module, Creating Arrays, Vectorized Functions, Exception Handling.

UNIT IV (24 Hours)

Visualisation of Data using Matplotlib

Matplotlib Module - Multiple plots, Polar plots, Pie Charts, Plotting Sine, Log, Exponential, Plotting mathematical functions, Fourier Series

Numerical Methods: Derivative of a function, Numerical Integration, Polynomials, Finding roots of an equation, System of Linear Equations, Least Squares Fitting, Interpolation.

Recommended Textbooks:

1. Introduction To Matlab, Ross L. Spencer And Michael Ware
2. Artificial Neural Networks-B.Vegnanarayana
3. Duane C. Hanselman and Bruce L. Littlefield (2004).*Mastering MATLAB 7*.Prentice Hall
4. Introduction to Matlab, R.L. Spencer & M. Ware, Brigham Young University (2010)
5. Python for Education, Ajith Kumar B.P.,
6. Computational Physics Problem Solving with Python, RUBIN H. LANDAU, JOSE, CRISTIAN, Publisher: Wiley, Third Edition.

Recommended References:

1. J.M. Thijssen (1999). *Computational Physics*.Cambridge University Press.
2. NEURAL NETWORKS-Algorithms, Applications and Programming Techniques – James A Freeman and David M. Skapura
3. Tao Pang (1997). *An Introduction to computational physics* .Cambridge University Press.
4. Rubin H. Landau (1997). *Computational Physics: Problem solving with computers*. John Wiley.
5. James B. Scarborough. *Numerical mathematical analysis*. Oxford IBH
6. Python Essential Reference, David M. Beazley, Pearson Education
7. Core Python Programming, Wesley J Chun, Pearson Education
8. www.python.org

PH820302 PRACTICALS IN INFORMATICS

Total Credit 5

Total hours 180

1. (a)Create an interface having two methods – division and modulus. Create a class which overrides these methods.

   (b)Write and execute a program in java to display the names and register numbers of students. Initialize the respective array variables for 10 students. Handle ArrayIndexOutOfBounds Exception so that any such problem does not cause illegal termination of program.
2. Write a java program to find the area of Square, Rectangle, and Triangle using the concept of polymorphism.
3. A program to demonstrate multilevel inheritance.
4. Write and execute a program to introduce method overloading.
5. Write a java program to create a thread using Thread class.
6. Write a java program to create and implement an Interface.
7. Define a class called student with data members name, roll number and age. Write a suitable constructor and method output() to display the details. Derive another class student1 from student with data members height and weight. Write a program to read and display data.
8. (a)Write a program for generating two threads, one for printing even numbers and the other for printing odd numbers.

   (b)Write a program to read a statement from console, covert it into upper case again print it on console.
9. Write and execute a java program to display an ordinary working calculator on the screen. The digits and arithmetic signs are to be displayed on the buttons.
10. Write a program to introduce a ‘text filed’ and ‘text area’ activated by three buttons.
11. Write and execute an applet in Java to display the applet with following conditions

    (a) There should be a menu with options LINE,RECTANGLE, CIRCLE, ELLIPSE and EXIT.

    (b) If the option ELLIPSE is selected and if the mouse is clicked and dragged, an ellipse with varying size should be displayed on the screen.

(c) Suitable display should be generated when other options other than EXIT are selected.

(d) When EXIT is selected the applet should exit from the screen.

12. Write a Java applet which reads your name and address in different text fields and when a button named find is pressed the sum of the length of characters in name and address is displayed in another text field. Use appropriate colors and layout to make your applet look good.
13. (a)Create a Web page with appropriate content and insert an image towards the left hand side of the page. When the user clicks on the image it should open another web page.(b) Create a Web page. When the user clicks on the link it should go to the bottom of the page.
14. Design a single page web site for a university containing a description of the courses offered. It should also contain some general information about the university such as its history, the campus and its unique features and so on. The site should be colored and each section should have a different color.
15. Make out a brief Bio – data of yours and code it as an HTML page. Use tables to show your academic history.
16. Create a web page having two frames, one containing the links and when the links are clicked appropriate contents should be displayed in frame2.
17. Design a page with a text box called “name” and a button with label “enter”. When you click on the button another page should open, with the message “welcome <name>” where the name should be equal to the name entered in the first page.
18. Create a web page having minimum of four pages with home page containing links to other pages and also should have return links. Use maximum number of tags in the program.
19. Create an HTML form that inputs student details and when submitted display the same on the HTML page.
20. Design a biodata form.
21. Create a web page showing your personal information using text boxes, radio buttons, check boxes, Select tag and Pull Down lists. The form should contain First name, Middle name, Last name, Date of Birth, Marital status, Gender, Pin code, Country, Education, Annual income, City, state, Occupation, Industry etc.

22. (a). Write a Java Script code block using arrays and generate the current date in words. This should include the day, the month and the year.(b) Write a java script code that converts the entered text into upper case.(c) Write a program to display the multiplication table.
23. (a)Write a Java script code to accept radius and display the area of the circle.(b) Write a code to create a Scrolling text in a text box. (c) Using Java script create a digital clock.

24. Write and execute a Matlab program to simulate a single phase half – wave diode rectifier supplying a resistive load of 2 ohms from an ac source of 230V and 50Hz. Draw the wave form of output voltage and current delivered to the load with following assumptions.
    (a) The switch is ideal, the diode resistance Rd = ; source inductance Ls = 0
    (b) The switch is ideal, the diode resistance RD = 0.2 ohms; source inductance Ls = 0
25. Write and execute a Matlab program to design an IIR low pass filter using Butterworth prototype and impulse invariant transformation.

BUNCH D – THEORETICAL PHYSICS

PH830301 : GENERAL RELATIVITY AND APPLICATIONS

Total Credits : 3

Total Hours : 54

Objectives: To introduce General Relativity and its mathematical techniques along with important applications so as to initiate students towards a wide spectrum of research problems that make use of these.

Unit I (18 hours)Basics of relativity, Tensor analysis

1.1 Overview of special relativity-Principles of special relativity, 1.2 Line interval - Proper time, 1.3 Lorentz transformation, 1.4 Minkowski spacetime Lightcones, 1.5 Relativistic momentum 4-vectors, 1.6 Lorentz transformation of electromagnetic field, 1.7 Energy Momentum tensor for a fluid, perfect fluid, 1.8 Conceptual foundations of GR and curved spacetime - Principle of equivalence, 1.9 Connection between gravity and geometry, 1.10 Metric tensor and its properties, metric in Newtonian limit 1.11 Concept of curved spaces and spacetimes, 1.12 Tangent space and four vectors, Tensor algebra, 1.13 Tensor calculus, Covariant differentiation.

Unit II (18 Hours) Einstein's field equations

2.1 Parallel transport, 2.2Riemann curvature tensor, 2.3 Geodesics - Particle trajectories in gravitational field, 2.4 Einstein's field equations, 2.5 Definition of the stress tensor, 2.6 Bianchi identities and conservation of the stress tensor, 2.7 Einstein's equations for weak gravitational fields, Newtonian limit. 2.8 Derivation of Schwarzschild metric, Basic properties of Schwarzschild metric coordinate- systems and nature of R=2M surface, 2.8 Effective potential for particle orbits in Schwarzschild metric, 2.8 Deflection of ultra relativistic particles, 2.9 Gravitational red-shift.

Unit III (9 Hours)Applications of General Relativity

3.1 Gravitational waves - Wave equation in linearised theory, 3.2 Plane waves, 3.3 Transverse traceless gauge, 3.4 Effect on test particles, 3.5 Principles of detection and generation of gravitational waves, 3.6 Types of detectors(qualitative), 3.7 Hulse Taylor binary pulsar.

Unit IV (9 Hours) Cosmology

4.1 Models of the universe, 4.2 Einstein universe, 4.3 Expanding universe, Simplifying assumptions, 4.4 Hubble's law, 4.5 Friedmann models: Einstein equations, 4.6 Energy tensors - Solutions to Friedman equations.

Text Books:

1. First course in general relativity, B. F. Schutz; Cambridge University Press. (Units I, II, III)
2. Introduction to Cosmology, 3rd Edition, J. V. Narlikar, Cambridge University Press. (Unit IV)

Reference:

1. Gravitation and Cosmology: Principles and Applications of General Theory of Relativity, Steven Weinberg; John Wiley & Sons.
2. Classical Theory of Fields, Vol. 2: L. D. Landau and E. M. Lifshitz, Oxford : Pergamon Press.
3. General Relativity and Cosmology, J. V. Narlikar Delhi: Macmillan Company of India Ltd.
4. Gravitation, Charles W. Misner, Kip S. Thorne, John A. Wheeler; W. H. Freeman and Company.

PH830402: NONLINEAR DYNAMICS

Total Credits : 3

Total Hours : 90

Objective: To introduce the students the Philosophy and Methods of Nonlinear dynamics. For a complete course, numerical experiments are necessary and a portion of the time is allocated for computational implementation of a few important topics in each unit.

Unit I (33 hrs)

1.1 A brief history of Nonlinear dynamics. 1.2 Importance of Nonlinear dynamics. 1.3 World as a dynamical system. 1.4 One dimensional flows. 1.5 fixed points. 1.6 Linear stability analysis. 1.7 Bifurcations. 1.8 saddle-Node bifurcation. 1.9 Transcritical bifurcation. 1.10 Pitchfork bifurcation. 1.11 Potentials. 1.12 Uniform and non uniform oscillators. 1.13 Two dimensional flows. 1.14 Phase portraits. 1.15 existence and uniqueness. 1.16 Fixed points and linearization linearization (of one dimensional flows). 1.17 Limit cycles. 1.18 Poincare Bendixon theorem.

Unit II (12 hrs)

2.1 Phase portraits. 2.2 Numerical computation of phase portraits. 2.3 Fixed points and linearization (of two dimensional flows). 2.4 Lorenz equations. simple properties of Lorenz equations. 2.5 Chaos on a strange attractor. 2.6 Defining Attractor and Strange attractor. 2.7 Lorenz map-ruling out stable limit cycles. 2.8 exploring parameter space.

Unit III (30 hrs)

3.1 One dimensional maps. 3.2 Fixed points and linear stability. 3.3 Logistic map: numerics. 3.4 Logistic map: analysis. 3.5 Liapunov exponent. 3.6 Fractals. 3.7 countable and uncountable sets. 3.8 Cantor set. 3.9 Dimension of self similar fractals. 3.10 Box dimension 3.11 Pointwise correlation dimensions. 3.11 Baker's map, Henon map 3.12 Elementary properties of Henon map 3.12 Roessler system. 3.13 Forced double well oscillator - Magneto-Elastic mechanical system.

Unit IV (15 hrs)

4.1 Chatter in Machine Tools 4.2 Correlations among data points. 4.3 Prediction of the displacement. 4.4 Reconstruction of Phase space. 4.5 Observed Chaos. 4.6 Embedding: Phase space reconstruction. 4.7 Geometry of Phase space reconstruction.
Text Book

1. Strogatz, Steven H. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering. Westview Press, 2014.
2. Analysis of Observed Chaotic Data, Abarbanel, Henry D.I., Springer, 1995.

Reference Books:

1. Deterministic Chaos, N. Kumar, Universities Press.
2. Chaos and Nonlinear Dynamics, RC. Hilborn, Oxford University Press.
3. Chaotic Dynamics: An Introduction, G.L. Baker, and J.P. Gollub, CUP, 1993.
4. Chaos in Dynamical System, E. Ott, Cambridge University Press.
5 . S. Neil Rasband, Chaotic Dynamics of Nonlinear Systems, Courier Dover Publications

PH830403: QUANTUM FIELD THEORY

Total Credits : 3

Total Hours : 90

Objectives: To introduce quantum field theory and its techniques so as to enable the student to take up independent study of advanced techniques as well as research in high energy physics, statistical mechanics, condensed matter physics and various newly emerging applications.

Unit I (27 Hours) Classical fields

1.1 Lagrangian, symmetries, gauge fields, 1.2 Real scalar – variational principle, Noether theorem, 1.3 Complex scalar field, Electromagnetic field, 1.4 Yang-Mills field, 1.5 Maxwell and Proca equations, Canonical quantization: 1.6 Klein-Gordon field as Harmonic Oscillators, 1.7 Klein-Gordon field in space-time, 1.8 Lorentz invariance in wave equations, 1.9 Dirac equation, 1.10 Free particle solutions, 1.11 Dirac Matrices, Dirac Field Bilinears, 1.12 Quantization of Dirac field, 1.13 Discrete Symmetries of Dirac Theory

Unit II (20 Hours)Interactions

2.1 Perturbation theory, 2.2 Perturbation Expansion of Correlation Functions, 2.3 Wick's Theorem, 2.4 Feynman diagrams, 2.5 Feynman rules for Fermions.

Unit III (20 hours) Path integral formulation of perturbation theory

3.1 Path integral formulation, 3.2 Perturbation theory and S-matrix, 3.3 Coulomb scattering, 3.4 Functional calculus and properties of path integrals,3.5 Generating functional for scalar fields - functional integration, 3.6 Free particle Green's functions, 3.7 Generating functional for interacting fields.

Unit IV (23 hours)S-matrix, Renormalization, Faddeev-Popov method

4.1. Phi-4 Theory, 4.2 Generating functional for connected diagrams, 4.3 Fermions using functional methods, 4.4 S-matrix and reduction formula, 4.5 Divergences in Phi-4 theory, 4.6 Dimensional regularization of Phi-4 theory, 4.7 Renormalization of Phi-4 theory, 4.8 Faddeev-Popov quantization, Feynman rules for QED, 4.9 Ward-Takahashi identity.

Textbooks

1. Quantum Field Theory, Lewis H Ryder, 2nd Edn, Cambridge University Press (1996). (1.1– 1.5 of Unit I, Unit III, Unit IV)
2. An Introduction to Quantum Field Theory, Michael E Peskin, Daniel V Schroeder, Westview (1995). (1.6 – 1.13 of Unit I, Unit II)

Reference:

1. The Quantum Theory of Fields, Steven Weinberg, Cambridge University Press.
2. Quantum Field Theory, M Srednicki, Cambridge University Press (1996).
3. Critical Properties of Phi-4 Theories, Hagen Kleinert, Verena Schulte-Frohlinde, World Scientific (2001)
4. Relativistic Quantum Fields, J D Bjorken and S D Drell, McGraw Hill Company
5. Quantum Field Theory, C Itzykson, J-B Zuber, McGraw Hill Inc (1980).
6. Field theory: A Modern Primer, P Ramond, Benjamin-Cummins Publishing Co (1981)
7. Introduction to the Theory of Quantized Fields, N N Bogoliubov, D V Shirkov New York, (1959)

PH830302 : SPECIAL COMPUTATIONAL PRACTICALS

Total credit: 5

Total hours: 180

Objective: Equip the students to develop algorithms and programs for numerical experiments and handling data. Students may use any programming language and/or packages of their choice.

1. Trajectory of motion of (a) projectile without air resistance (b) projectile with air resistance.
2. Phase space of the harmonic oscillator with and without damping.
3. Phase space of a pendulum with and without damping.
4. Phase space of a driven damped pendulum.
5. Lyapunov exponents of the Logistic map with varying parameters.
6. Self similar structure of the Henon Map.
7. Phase space of chaotic Duffing Oscillator.
8. Bifurcation diagram of the Duffing Oscillator..
9. Poincaré section of chaotic Duffing Oscillator.
10. Bifurcation diagram of the Lorenz system.
11. Bifurcation diagram of the Roessler system system
12. Poincaré section of the Lorenz system.
13. Poincaré section of the Roessler system.
14. Lyapunov exponents of the Lorenz system.
15. Plotting of Julia set.
16. Plotting of Mandelbrot set.

CHAPTER IV

PARALLEL PG-CSS PHYSICS PROGRAMME

In this chapter, the details of a parallel PG-CSS programme is presented. This M.Sc. Physics-Material Science programme is taught in Catholicate College, Pathanamthitta affiliated to MG University. The number of hours per week, number of credit per course and the total hours per semester allocated to this course will remain the same as those for M.Sc. Physics programme as described in chapter 1. This programme has 12 core courses and 3 elective courses. The examination pattern and question paper model remain the same as that described in chapter 2. The details are given in the table.

4.1 COURSE AND COURSE CODE OF M.Sc. PHYSICS - MATERIAL SCIENCE

Course Code

The first two letters '**PH'** stand for Physics and the digit '**02'** stands for model two: Material Science. The fifth and sixth character of the Code running from '**01** to **04'** indicates the semester concerned. All others are same as explained in section 1.5 of general description. Course and Course code of M.Sc. Physics - Material Science are given in Table.4.1

Table 4.1: Structure of M.Sc. Physics - Material Science under PG-CSS 2019

SEM	NAME OF THE COURSE WITH COURSE CODE	No. of credit	No.of hrs/ week	No.of hrs/ SEM
I	**PH020101:** APPLIED MATHEMATICS FOR PHYSICS- I	4	4	72
	PH020102: BASIC QUANTUM MECHANICS	4	4	72
	PH020103: CONDENSED MATTER PHYSICS	4	4	72
	PH020104: CLASSICAL MECHANICS AND RELATIVITY	3	3	54
	PH020105: GENERALPHYSICS PRACTICALS	4	10	180
II	**PH020201:** APPLIED MATHEMATICS FOR PHYSICS – II	4	4	72

	PH020202:ELECTRODYNAMICS AND ELECTROMAGNETIC WAVES	**4**	**4**	**72**
	PH020203:ADVANCED ELECTRONICS AND COMMUNICATION	**4**	**4**	**72**
	PH020204: ADVANCED NUCLEAR PHYSICS	**4**	**3**	**54**
	PH020205: ELECTRONICS PRACTICALS	**4**	**10**	**180**
III	**PH020301:**STATISTICAL PHYSICS AND ASTROPHYSICS	**4**	**4**	**72**
	PH020302:NUMERICAL METHODS IN PHYSICS	**4**	**4**	**72**
	PH020303: ADVANCED QUANTUM MECHANICS	**4**	**4**	**72**
	ELECTIVE -1	**3**	**3**	**54**
	PH020304:COMPUTATIONAL AND ADVANCED ELECTRONICS PRACTICALS	**5**	**10**	**180**
IV	**PH020401:** ATOMIC AND MOLECULAR SPECTROSCOPY	**4**	**5**	**90**
	ELECTIVE -2	**3**	**5**	**90**
	ELECTIVE-3	**3**	**5**	**90**
	ELECTIVE PRACTICALS	**4**	**10**	**180**
	PH020402: PROJECT	**5**	**-**	**-**
	PH020403:COMPREHENSIVE VIVA VOCE	**2**	**-**	**-**
	Total Credit	**80**		

The Elective Bunches:

There are two Electives Bunches offered in this parallel PG-CSS Physics programme. Each elective consists of a bunch of three theory courses and one laboratory course. The first theory course is placed in the Semester III, while the second and third theory and the laboratory course of a bunch are in Semester IV. An institution can select only one Elective Bunch in an academic year. The course structure of the Electives Bunches is given in Table 4.2

The Electives Bunches are named,

(i) Bunch A : Material Science-I

(ii) Bunch B : Material Science-II

Table 4.2: The Elective Bunch

Bunch A: Material Science-I **Course code: 84**

Semester	Course Code	Course Title	No. of hrs / week	Credits
3	PH840301	THIN FILM SCIENCE AND CRYSTAL GROWTH TECHNIQUES	3	3
4	PH840402	NANOSCIENCE AND NANOTECHNOLOGY	5	3
4	PH840403	MATERIALS SCIENCE AND ENGINEERING	5	3
4	PH840404	MATERIAL SCIENCE PRACTICALS	10	5

Bunch B: Material Science-II **Course code: 85**

Semester	Course Code	Course Title	No. of hrs / week	Credits
3	PH850301	OPTOELECTRONICS	3	3
4	PH850402	SEMICONDUCTOR DEVICES	5	3
4	PH850403	CERAMICS AND BIOMATERIALS	5	3
4	PH850404	ADVANCED MATERIAL SCIENCE PRACTICALS	10	5

4.2 SYLLABUS

SEMESTER – I

PH020101: APPLIED MATHEMATICS FOR PHYSICS- I

Credit-4 (72 hours)

Objective of the course: The purpose of the course is to introduce students to methods of mathematical physics and to develop required mathematical skills to solve problems in quantum mechanics, electrodynamics and other fields of theoretical physics. The first objective of this course is to develop student's facility with certain mathematical techniques. The second objective is to highlight applications of mathematical methods to physical systems. Applications shed light on both the mathematics and the logic underpinning physical models. This allows students to develop valuable intuition for subsequent courses where these same methods will be applied.

Unit I

Vector Algebra and Vector Spaces (18 hrs)

1.1 Review of vector analysis-vector calculus- Differential Calculus: Gradient, Divergence, Curl - Successive applications of grad – Integral calculus: line, surface & volume integrals 1.2 Fundamental theorem for gradients, divergences and curls - Equation of continuity - Potential theory - Gauss's law and Poissons equation 1.3 Orthogonal curvilinear coordinates: Spherical & Cylindrical - Differential vector operators in orthogonal coordinates 1.4 Linear vector spaces 1.4.1 Self adjoint, unitary & projection operators –Eigen values&Eigen vectors of self adjoint operators 1.5 Inner product space-Schmidtorthogonalisation - Hilbert space 1.6 Schwartz inequality

Text Books

1. Mathematical Methods for Physicists, G.B. Arfken & H.J. Weber 4^{th} Edition, Academic Press (Chapter 1 & 2)
2. Mathematical Physics, P.K Chattopadhyay, New Age International (chapter 7)
3. Theory and problems of vector analysis, Murray R. Spiegel (Schaum's outline series)

Unit II

Matrices, Error analysis and Probability (12 hrs)

2.1 The algebra of matrices - Special matrices 2.2 Elementary transformations - Similarity transformation - unitary and orthogonal transformation.2.3 Matrix inversion (Gauss-Jordan inversion method) - Solution of linear equation- Gausselimination method- 2.4Eigen values and eigenvectors - Diagonalisation using normalized eigenvectors –2.5Cayley-Hamilton theorem 2.6Linear operators. Matrix representation - Orthoganal, Unitary and Hermitian matrices, normal matrices, Pauli spin matrices – Matrix mechanics (Qualitative Ideas)

Text Books

1. Mathematical Methods for Physicists, G.B. Arfken&H.J. Weber 4th Edition, Academic Press (Chapter 3)
2. Mathematical Physics, P.K Chattopadhyay, New Age International (Chapter 7)
3. Mathematical Physics, H.K. Dass, S. Chand & Co. New Delhi.

Error analysis and Probability (6 hrs)

2.7 Error analysis- Propagation of errors- Standard deviation 2.8 Binomial, Poisson and Gaussian distributions.

Text Books

1. Mathematical methods for Physics and Engineering, K.F. Riley, M.P Hobson, S. J. Bence, Cambridge University Press (Chapter 24)
2. Mathematical Methods for Physicists, G.B. Arfken&H.J. Weber 4th Edition, Academic Press. (Chapter 19)
3. An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements, John R. Taylor - Univ. Science Books

Unit III

Linear Differential Equations and Special Functions (20 hrs)

3.1 Linear ordinary differential equations of first & second order 3.2 Gamma and Beta Functions (review of properties) 3.3 Dirac delta function – its property and integral forms3.4 Bessel's differential equations3.5 Legendre differential equations 3.6 Hermite differential equation 3.7 Laguerre differential equation Generating Functions – recurrence relation – orthogonality – Rodrigue's formula (to be discussed for all equations).

Text Books

1. Mathematical Methods for Physicists, G.B. Arfken&H.J. Weber 4th Edition, Academic Press
2. Mathematical Physics, B.S Rajput, PragatiPrakashan

Unit IV

Tensors (16 hrs)

4.1 Tensor analysis - Coordinate transformations 4.1.1 Rank of a tensor, Classification of tensors 4.2 Addition, Subtraction 4.3 Outer product, Inner product and Contraction 4.3.1 Symmetric and antisymmetric tensors 4.4 Quotient law4.5 Metric tensor - Conjugate tensor 4.5.1 Levi-Civita symbol - Kronecker delta function 4.6 Associated tensors - Raising and lowering of indices – geodesic4.7 The Christoffel symbols and their transformation laws 4.7.1Covariant derivative of tensors.

Text Books

1. Introduction to Mathematical Physics, Charlie Harper, PHI
2. Vector analysis and tensors, Schaum's outline series, M.R. Spiegel, Seymour Lipschutz, Dennis Spellman, McGraw Hill
3. Mathematical Physics, B.S. Rajput, Y. Prakash 9th Ed, Pragati Prakashan
4. Tensor Calculus: Theory and problems, A. N. Srivastava, Universities Press
5. Matrices and Tensors in Physics – A W Joshi

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken&H.J. Weber 4th Edition, Academic Press
2. Mathematical Physics, B.D. Gupta, VikasPub.House, New Delhi
3. Advanced Engineering Mathematics, E. Kreyszig, 7th Ed., John Wiley
4. Introduction to mathematical methods in physics, G.Fletcher, Tata McGraw Hill
5. Advanced engineering mathematics, C.R. Wylie, & L C Barrett, Tata McGraw Hill
6. Advanced Mathematics for Engineering and Physics, L.A. Pipes &L.R.Harvill, Tata McGraw Hill
7. Mathematical Methods in Physics, J. Mathew & R.L. Walker, India Book House.
8. Mathematical Physics, H.K. Dass, S. Chand & Co. New Delhi.

PH020102: BASIC QUANTUM MECHANICS

Credit-4 (72 hours)

Objective of the course: After studying the course, the student will (i) understand the fundamental concepts of quantum mechanics-operator formalism-Bra, Ket-representation –wave functions - and be able to apply them to various problems,(ii) understand the physics of time evolution and different pictures in quantum mechanics,(iii) understand not only the concept of angular momentum and its addition but also the rotation operator and its significance,(iv) understand the concept of perturbation and get ideas of different approximation methods –WKB method, Variation method etc. This course aims to give a brief introduction to Dirac's approach to quantum mechanics, operator formalism and its applications.

Unit I

Fundamental Concepts (16 hrs)

1.1 The Stern - Gerlach experiment- Dirac notation for state vectors- Ket space, bra space, Hilbert Space 1.2 Algebraicmanipulation of operators – unitary operators &Hermitian operators-Eigenkets and eigenvalues – concept of complete set. 1.3 Matrix representation of operators, kets & Bras- Expectation values, Measurements, Observables - Generalized uncertainty relation 1.4 Change of basis – Transformation Operator, transformation matrix ,unitary equivalent observables 1.5 Position, Momentum and Translation-Infinitesimal translation operator and its properties 1.6 Wave functions in position space and momentum space - Relations between operator formalism and wave function formalism 1.7 Gaussian wave packet –Computation of expectation values x, x^2, p and p^2

Text Book

1. Modern Quantum Mechanics, J. J. Sakurai, Pearson Education (Chapter 1)

Unit II

Time Evolution and Pictures of Quantum Mechanics (18 hrs)

2.1 Time evolution operator and its properties 2.1.1 Schrodinger equation for the time evolution operator 2.1.2 Energy eigenkets - Time dependence of expectation values 2.2 Time energy uncertainty relation 2.3 Schrodinger picture and Heisenberg picture 2.3.1 Behaviour of state kets and observables in Schrodinger picture and Heisenberg picture 2.3.2 Heisenberg equation of motion- Ehrenfest's theorem 2.4 Time evolution of base kets - Transition amplitude 2.5 Energy eigenket and eigen values of a simple harmonic oscillator using creation and annihilation operators-Time development of the Oscillator

Text Book

1. Modern Quantum Mechanics, J.J. Sakurai, Pearson Education(Chapter 2)

Unit III

Angular momentum (18 hrs)

3.1Infinitesimal rotations in quantum mechanics 3.1.1 Representation of the rotation operator - Rotation matrix 3.1.2 Properties of the rotation matrix - Orbital angular momentum as a rotation generator 3.2 Fundamental commutation relations of angular momentum 3.2.1 Commutation relations for J^2, J_Z - Eigenvalues of J^2 and J_Z - Matrix elements of angular momentum operators 3.3 Rotation operator for spin ½ system - Pauli two component formalism – Pauli spin matrices 3.4 Addition of angular momentum-Computation of Clebsch-Gordon coefficients

Text Book

1. Modern Quantum Mechanics, J.J. Sakurai, Pearson Education

Unit IV

Perturbation Theory (7 hrs)

4.1 Nondegenerate Energy levels - First and second order corrections in energy and wave function - Anharmonic oscillator 4.1.1 Degenerate Energy levels - First order correction-the ground state of Helium 4.2 First order Stark effect 4.3 Zeeman effect in Hydrogen atom

The Variation Method (6 hrs)

4.4 The variational principle-Rayleigh-Ritz method 4.4.1Applications-The ground state of Helium and Hydrogen molecule ion

WKB Approximation (7 hrs)

4.5 The WKB method - The connection formula (proof not needed) - validity of WKB method 4.6 Barrier penetration-Alpha Emission

Text Book

1. Quantum Mechanics, G Aruldhas, PHI, 2002, (Chapter 9, 10, 11)

Reference Books:

1. A Modern approach to quantum mechanics, John S. Townsend, Viva Books MGH.
2. Basic Quantum Mechanics, A. Ghatak, Macmillan India 1996
3. Quantum Mechanics, an Introduction, W Greiner, Springer Verlag
4. Quantum Mechanics, E. Merzbacher, John Wiley, 1996
5. Introduction to Quantum Mechanics, D.J. Griffiths, Pearson.
6. Quantum Mechanics, L.I. Schiff, Tata McGraw Hill
7. A Text Book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, TMGH.
8. Quantum Mechanics, Concepts and Applications, N. Zettily, John Wiley &Sons.
9. Fundamentals of Quantum Mechanics Y.R. Waghmare, S Chand & Co.
10. Advanced Quantum Mechanics, Satya Prakash. KedarNathRamnath Publications.

PH020103: CONDENSED MATTER PHYSICS

Credit-4 (72 hours)

Objective of the course: The objectives of this subject are to challenge the students to expand their knowledge of condensed matter physics and provide a foundation for further advanced studies. To develop a deep understanding of how condensed matter is characterised on the atomic scale.To broaden their appreciation of how condensed matter physics integrates into the discipline of physics overall.To understand the systems and acquire a fundamental understanding of a range of physical phenomena in condensed matter systems. Also to understand the phenomenon of superconductivity and their relation with the magnetic properties of materials.

Unit I

Lattice Vibrations and Thermal properties of Solids (16 hrs)

1.1 Phonons - Quantization of lattice vibrations - Vibrations of monatomic and diatomic lattices - acoustic and optical modes 1.2 Phonon Momentum - Inelastic scattering of neutrons by phonons 1.3 Anharmonic crystal Interactions - Thermal Expansion 1.4 Lattice Heat Capacity 1.4.1 Einstein model - Density of modes in one and three dimensions 1.4.2 Debye model of lattice heat capacity – Debye's T^3 law 1.5 Thermal conductivity of solids - Thermal resistance of solids - N process – U process.

Text books

1.Solid State Physics-Structure and Properties of materials, M.A.Wahab. Narosa.

2. Solid State Physics, A.J.Dekker, Macmillan, 1967

3. Solid State Physics-J.S. Blakemore, Cambridge University Press.

Unit II

Free Electron Theory (8 hrs)

2.1 Energy levels and density of states in one dimension - Free electron gas in three dimensions 2.2 F D Statistics 2.3 Heat capacity of the electron gas 2.4 Electrical conductivity of metals and Ohm's law 2.4.1 Thermal conductivity of metals - Wiedemann-Franz law 2.4 Motion of electrons in Electric and magnetic fields - Hall effect.

Band Theory of Solids (16 hrs)

2.5 Effective mass of electron 2.6 Bloch theorem - Kronig-Penney model 2.7 Brillouin zone construction in one and two dimensions – extended, reduced and periodic zone scheme of Brillouin zone 2.8 Nearly free electron model- Tight binding Approximation- OPW method- Pseudopotential method 2.9 Construction of Fermi surfaces 2.10 Experimental study of Fermi surfaces-Anomalous skin effect, cyclotron resonance, de Hass-Van Alphen Effect.

Text books

1.Solid State Physics-Structure and Properties of materials, M.A.Wahab. Narosa.

2. Solid State Physics, A.J.Dekker, Macmillan, 1967

Unit III

Dielectrics and Ferroelectrics (8 hrs)

3.1 Theory of Dielectrics: Polarisation - Dielectric constant - Local Electric field - Dielectric polarisability 3.1.1 Polarisation from dipole orientation - Dielectric losses 3.2 Ferroelectric crystals 3.2.1 Landau theory of ferroelectric phase transitions 3.2.2 Ferroelectric domain 3.3 Antiferroelectricity 3.4. Piezoelectricity - Applications of Piezoelectric Crystals.

Superconductivity (10 hrs)

3.5 Sources of super conductivity 3.5.1 The Meissner Effect-Heat capacity- Energy gap - Isotope effect 3.5.2 Free energy of superconductor in magnetic field and the stabilization energy 3.5.3 London equation and penetration of magnetic field 3.6 Cooper pairs and the BCS ground state 3.7 Flux quantization 3.8 Single particle tunneling 3.8.1 DC and AC Josephson effects 3.9 High Tc superconductors - Applications of Superconductivity.

Text books

1. Solid State Physics-Structure and Properties of materials, M.A.Wahab.Narosa.
2. Solid State Physics, S.O.Pillai, New Age International 6th Edn. 2010

Unit IV

Magnetic properties (14 hrs)

4.1 Diamagnetism and Para magnetism 4.1.1 Langevin's diamagnetism 4.2 Cooling by adiabatic Demagnetization 4.3 Quantum theory of paramagnetism - Hund's rule 4.3.1 Paramagnetic susceptibility of conduction electrons 4.4 Ferro, Anti and Ferri magnetism: Curie point and the exchange integral 4.4.1 Ferrimagnetic order - Curie temperature and susceptibility of ferrimagnets 4.5 Antiferromagnetic order - Weiss theory of ferromagnetism - Ferromagnetic domains.

Text books

1. Solid State Physics-Structure and Properties of materials, M.A.Wahab.Narosa.
2. Solid State Physics, S.O.Pillai, New Age International 6th Edn. 2010

Reference Books:

1. Introduction to Theory of Solids, H.M. Rosenberg, Prentice Hall
2. Solid State Physics, N.W.Ashcroft and N.D. Mermin, CengageLearning Pub.
3. Elements of Solid State Physics, J.P. Srivastava, Prentice Hall ofIndia (2nd Edition)
4. Solid State Physics-J.S. Blakemore, Cambridge University Press.
5. Solid State Physics, Gupta Kumar, Pragati Prakasan
6. Introduction to Solid State Physics, C. Kittel, Wiley Eastern.
7. Elementary Solid State Physics, M. Ali Omar, Pearson.

PH020104: CLASSICAL MECHANICS AND RELATIVITY

Credit-3 (54 hours)

Objective of the course: After completing the course, the student will (1) understand the fundamental concepts of the Lagrangian and the Hamiltonian methods and be able to apply them to various problems, learn Hamilton-Jacobi method and the concept of action- angle variables. (2) Understand the physics of small oscillation and the concepts of canonical transformations and Poison brackets, (3) understand the basic ideas of rigid body dynamics, (4) This course also provide the basic ideas of special and general theory of relativity , non-linear dynamics and chaos.

Unit I

Lagrangian and Hamiltonian Methods (18 hrs)

1.1 Review of Lagrangian dynamics-Applications of Lagrange's equations-Velocity dependent potentials 1.2 Hamilton's equations of motion -Cyclic coordinates - Symmetry and conservation theorems 1.3 Variational principle and Hamilton's equations - Physical significance of principle of least action –Proof1.4 Canonical transformations 1.4.1 Equation of canonical transformation-example of canonical transformation-harmonic Oscillator 1.5 Lagrange brackets- Poisson brackets – Equation of motion in Poisson bracket form – Canonical invariance of poisson bracket 1.6 Hamilton's characteristic function 1.7 Hamilton Jacobi theory – Harmonic Oscillator- Kepler Problem-1.8 Action angle variables – Harmonic Oscillator- Kepler problem.

Text books

1. Classical Mechanics, J C Upadhyaya
2. Classical Mechanics , G Aruldas
3. Classical Mechanics , H.Goldstein

Unit II

Rigid Body Dynamics (18 hrs)

2.1 Independent Coordinates 2.2 Euler's Angles- Euler's equation of motion 2.3 Infinitesimal rotation – Rate of change of a vector 2.4 Force free motion of a symmetric top - Heavy Symmetric top 2.5 Coriolis Force and its effects. 2.6 Theory of Small Oscillations -Formulation of the problem – Eigen value equation –

Normalcoordinates- normal modes- Two coupled oscillators -Oscillations of linear triatomic molecules

Text books

1. Classical Mechanics, J C Upadhyaya
2. Classical Mechanics , G Aruldas
3. Classical Mechanics , H.Goldstein

Unit III

Special and General Theory of relativity (18 hrs)

3.1 The postulates of Special Theory of relativity 3.2 Relativistic kinematics and mass–energy equivalence 3.3 Relativistic Lagrangian and Hamiltonian of a particle-Lorentz co-variance 3.4 Four vectors - Invariance of Maxwell's equations under Lorentz transformations 3.5 General theory of relativity-Principle of Equivalence-space curvature-Gravitational red shift. 3.6 Nonlinear dynamics and introduction to chaos - Linear and Nonlinear systems3.6.1 Phase space dynamics-Bifurcation-logistic map- Attractors-Universality of chaos-Fractals (Qualitative ideas only).

Text book

1. Classical Mechanics, G Aruldas

Reference Books:

1. Classical mechanics, N. C. Rana & P.S. Joag - TMGH.
2. Classical mechanics, Satyaprakash, Sultan Chand & Company.
3. Classical mechanics, Gupta & Kumar, Pragati Prakasan.
4. Classical Mechanics, A.K. Raychauduri, Oxford Univ. Press

PH020105: GENERAL PHYSICS PRACTICALS

Credit-4 (180 hours)

(Minimum of 12 Experiments with Error analysis of the experiment is to be done)

1. Magnetic susceptibility - Quincke's method
2. Magnetic susceptibility - Guoys method
3. Y, n, σ Cornu's method, (a) Elliptical fringes
4. Y, n, σ Cornu's method, (b) Hyperbolic fringes
5. Young's modulus and Poisson's ratio – Koenig's method
6. Michelson interferometer – λ and dλ/ thickness of mica
7. Absorption spectrum-$KMnO_4$ solution- telescope and scale arrangement- Hartmann'sformula
8. e/m of electron – Thomson's method
9. Thermistor characteristics
10. Determination of e/k – silicon transistor
11. Hydrogen spectrum – Rydberg constant
12. Ultrasonic – Acousto-optic technique- elastic property of a liquid.
13. Oscillating disc – viscosity of liquid
14. Determination of e – Milliken's method
15. Characteristics of a photodiode
16. B-H curve – Anchor ring
17. Mutual inductance – Carey Foster's bridge
18. Self and mutual inductance – Anderson's bridge
19. Arc spectrum of Iron, Copper and Brass
20. Absorption spectrum of Iodine- photographic method
21. Raman effect in liquids – plate measurement
22. Identification of elements by spectroscopic method
23. Dielectric constant of a non-polar liquid
24. Temperature dependence of a ceramic capacitor and verification of Curie Wiess law
25. Electrical and thermal conductivity of copper and determination of Lorentz Number
26. Silicon diode as temperature sensor

27. Verification of stephan's law and determination of Stephan's constant of Radiation
28. Diffraction of light by cross wire and wire mesh using laser.
29. Diffraction of light by double slit and grating using laser.
30. Cauchy's constant of liquid and liquid mixture using holoprism and spectrometer.
31. Surface tension of a liquid using Jaegger's method.
32. Characteristics of a phototransistor.
33. I-V characteristics of LED and LDR circuits.
34. Wavelength of He-Ne Laser using Vernier Calipers.
35. Identification of Fraunhoffer lines in solar spectrum.

SEMESTER – II

PH020201: APPLIED MATHEMATICS FOR PHYSICS – II

Credit-4 (72 hours)

Objective of the course: The purpose of the course is to introduce students to methods of mathematical physics and to develop required mathematical skills to solve problems in quantum mechanics, electrodynamics and other fields of theoretical physics. The first objective of this course is to develop students' facility with certain mathematical techniques. The second objective is to highlight applications of mathematical methods to physical systems. Applications shed light on both the mathematics and the logic underpinning physical models. This allows students to develop valuable intuition for subsequent courses where these same methods will be applied.

Unit I

Functions of Complex Variables and Analysis (20 hrs)

1.1 Introduction to complex variable - Analytic functions 1.2 Cauchy–Riemann equations - C-R equation in polar form 1.3 Cauchy's Integral Theorem - Cauchy's theorem for multiply connected domains 1.3.1 Cauchy's integral formula 1.3.2 Derivatives of analytic functions 1.4 Taylor & Laurent expansion 1.5 Singularities – Poles - Residue theorem 1.6 Evaluation of definite integrals

Text Books

1. Mathematical Methods for Physicists, G.B. Arfken&H.J. Weber 4thEdition, Academic Press.
2. Mathematical Physics, H.K. Dass and Dr. Rama Verma,S. Chand & Company Ltd., New Delhi.
3. Higher Engineering Mathematics- Dr. B.S. Grewal- 42ndEdn.-Khanna Pub.-New Delhi

Unit II

Elements of Abstract Algebra (18 hrs)

2.1 Introductory definitions and concepts - cyclic groups 2.2 groups of transformations- multiplication table-point groups 2.3 Reducible and irreducible representations 2.4 Schur's lemmas and Orthogonality theorem 2.5 Group character table 2.5.1 Applications in molecular and crystal physics 2.6 Lie group and lie algebra 2.6.1 3D rotational group 2.6.2 Poincare and Lorentz group 2.7 SU(2) and SU(3) groups.

Text Books

1. Elements of Group Theory for Physicists, A.W. Joshi, New Age India
2. Mathematical Physics with Classical mechanics-SatyaPrakash, SultanChand& Sons, New Delhi.
3. Group theory- Schaum's series, Benjamin Baumslag& Bruce Chandler, MGH.

Unit III

Fourier transforms and Fourier series (9 hrs)

3.1 Fourier transforms- Fourier Cosine and Sine Transform 3.1.1 Fourier Transform of Gaussian function - finite wave train 3.1.2 Momentum representation for hydrogen atom ground state & harmonic oscillator3.4 Fourier Series – Fourier series of square wave - full wave rectifier.

Laplace Transforms (9 hrs)

3.5 Introduction to Laplace Transform3.6 Inverse Laplace Transform3.7 Solution of differential equation3.7.1 L T Earth's mutation, LCR circuit, Driven oscillator with damping

Text Books

1. Mathematical Methods for Physicists, G.B. Arfken&H.J. Weber 4th Edition, Academic Press.
2. Mathematical Physics, H.K Dass&Dr. Rama Verma, S. Chand &Co.

Unit IV

Partial Differential Equations and Green's Functions (16 hrs)

4.1 Partial differential equation – characteristics - boundary conditions 4.2 classes of partial differential equations- Heat equation, Laplace's equation, Wave equation4.3 Non-linear partial differential equation and boundary conditions 4.4 Separation of variables in Cartesian, circular cylindrical and spherical polar coordinates 4.5 Non homogeneous equation - Green's function 4.6 Symmetry of Green's functions-Forms of Green functions4.6.1 Poisson's equation.

Text Books

1. Mathematical Methods for Physicists, G.B. Arfken& H.J. Weber, 4^{th} Edition, Academic Press.
2. Mathematical Physics with Classical mechanics-SatyaPrakash, SultanChand& Sons, New Delhi.
3. Mathematical Physics, B.S Rajput, PragatiPrakashan.

Reference Books:

1. Introduction to mathematical methods in physics, G.Fletcher, Tata McGraw Hill
2. Advanced engineering mathematics, C.R. Wylie, & L C Barrett, Tata McGraw Hill
3. Advanced Mathematics for Engineering and Physics, L.A. Pipes &L.R.Harvill, Tata McGrawHill.
4. Mathematical Methods in Physics, J. Mathew & R.L. Walker, India Book House.
5. Introduction to Mathematical Physics, Charlie Harper, PHI
6. Vector analysis and tensors, Schaum's outline series, M.R. Spiegel, Seymour Lipschutz, Dennis Spellman, McGraw Hill

PH020202: ELECTRODYNAMICS AND ELECTROMAGNETIC WAVES

Credit-4 (72 hours)

Objective of the course: To apprise the students regarding the concept of electrodynamics and Maxwell's equations and use them in various situations. At the end of the course, the leaner should able to (i) explain the use of Maxwell's equations in analysing the electromagnetic field due to time varying charge and current distribution (ii) describe the nature of electromagnetic waves and its propagation through different media and interfaces (iii) acquire knowledge of principles of relativistic electrodynamics (iv) discuss radiation from localized time varying electromagnetic sources.

Unit I

Electrostatics, Magnetostatics and Electrodynamics (18 hrs)

1.1 Laplace's Equation – in one, two, three dimensions and its solutions. 1.2 Boundary conditions and Uniqueness theorems - Conductors and the second Uniqueness theorem. 1.3 Multipole expansion - Approximate Potentials at large distances - The Monopole and Dipole terms - Origin of coordinates in Multipole expansions - The electric field of a dipole. 1.4 Magnetostatics- Divergence and curl of B- Magnetic vector potential - Magnetostatic boundary conditions-1.5 Multipole expansion of the vector potential - The auxiliary field H -Ampere's law in magnetized materials 1.6 Maxwell's Equations - Maxwell's equations in matter 1.6.1 Poynting`s theorem 1.6.2 Maxwell's StressTensor

Text Book

1. Introduction to Electrodynamics, David J Griffiths, PHI Learning, 2009 (Chapter 3,5,8)

Unit II

Electromagnetic Waves and Wave guides (18 hrs)

2.1 Electromagnetic Waves - Waves in one dimension 2.1.1 Electromagnetic waves in vacuum 2.1.2 Electromagnetic waves in matter 2.2 Reflection and transmission at normal incidence - Reflection and transmission at oblique incidence2.3 Absorption and Dispersion 2.4 Guided waves – waves between parallel conducting plane TE, TM and TEM waves 2.4.1 TE and TM Waves in Rectangular wave guides 2.4.2 The coaxial transmission lines

Text Book

1. Introduction to Electrodynamics, David J Griffiths, PHI Learning,2009

Unit III

Relativistic Electrodynamics (20 hrs)

3.1 Relativistic Mechanics - Proper time and velocity-Relativistic energy and Momentum 3.2 Relativistic Kinematics 3.2.1 Two-body scattering3.2.2 Decay of a particle 3.3 Relativistic dynamics.3.4 Relativistic Electrodynamics - Magnetism as a relativistic phenomenon 3.4.1 Transformation of the fields3.4.2 Electromagnetic field tensor 3.4.3 Electrodynamics in tensor notation 3.4.4 Potential formulation of relativistic electrodynamics**.**

Text Book

1. Introduction to Electrodynamics, David J Griffiths, PHI Learning,2009 (Chapter 12)

Unit IV

Radiation (16 hrs)

4.1 Potentials and Fields -The Potential formulation - Continuous Distributions 4.2 Retarded Potentials – Jefimenko's equations 4.3 Point Charges - Lienard-Wichert Potentials.4.4 Dipole radiation 4.4.1 Electric dipole radiation 4.4.2 Magnetic dipole radiation 4.4.3 Radiation from an arbitrary source. 4.4.4 Point Charges - Power radiated from a point charge.

Text Book

1. Introduction to Electrodynamics, David J Griffiths, PHI Learning.

Reference Books:

1. Classical Electrodynamics, J.D. Jackson 3rd Ed. Wiley, 1993.
2. Introduction to Classical Electrodynamics, Y K Lim, World Scientific,1986.
3. Electromagnetic waves and radiating systems, E.C. Jordan & K. G. Balmain PHI,1968
4. Electromagnetic fields, S. Sivanagaraju, C. Srinivasa Rao, New Age International.
5. Electromagnetic Waves and Fields, V. V. Sarwate, Wiley Eastern Ltd, New Age International
6. The Feymann Lectures in Physics, Vol. 2, R. P. Feymann, R.b. Leighton & M. Sands

PH020203: ADVANCED ELECTRONICS AND COMMUNICATION

Credit-4 (72 hours)

Objective of the course: To apprise the students regarding the concept of advanced electronics and communication. At the end of the course, the leaner should able to (i) explain the use of special semiconductor devices and different types of negative feed back characteristics. (ii) Describe the nature of practical op- amp and frequency response of an op-amp. (iii) Acquire knowledge of signal processing and communications (iv) discuss various types of active filters and oscillators.

UnitI

Special Semiconductor Devices (8hrs)

1.1 Review of Bipolar junction Transistor (BJT) biasing and characteristics- FET, JFET1.2 Structure and working, I/V Characteristics under different conditions, biasing circuits 1.3 MOSFET: Depletion and Enhancement type MOSFFT

Signal processing and Communication Systems (10hrs)

1.4 Modulation-Amplitude modulation - Frequency spectrum of AM- Representation of AM - Power relation in AM 1.5 Single Side Band: Evolution, Balanced modulator 1.6 Theory of frequency and Phase modulation, Generation of frequency modulation1.7Pulse communications - Pulse amplitude modulation– Pulse width, Pulse position, Pulsecode modulations. 1.8 Multiplexing techniques: Frequency division and time division multiplexing.

Text Book

1. Basic Electronics solid state, B.L Theraja,S (2005) Chand and company.
2. Electronic communication systems: Kennedy and Davis(4^{th} Edn).

UnitII

Negative Feedback Op-amp Characteristics (12 hrs)

2.1 Differential Amplifier 2.1.1 Inverting Amplifier-Non Inverting Amplifier-Block Diagram Representations 2.2 Voltage series feedback: Closed loop voltage gain, Difference Input voltage ideally zero-Input and output resistance with feed back-Band widthwith feed back – Total out put off set voltage with feedback 2.3 Voltage follower 2.4 Voltage shunt feed back amplifier: Closed loop voltage gain –Inverting input terminal at virtual ground- Input and output resistance with feedback-Band width with feed back- Total output offset voltage with feed back 2.5Current to voltage converter, Inverter 2.6 Differential amplifier with one Op-amp and two Op-amps.

The Practical Op-amp(6 hrs)

2.7 Input off set voltage, Input bias current, Input off set current-Total output offset voltage 2.8 Thermal drift- Effect of variation in power supply voltages on offset voltage 2.10 Change ininput offset voltage and inputoff se tcurrent withtime -Noise, Common mode configuration and CMRR.

Text Book

Op-amps and linear integrated circuits: R.A.Gayakwad.

UnitIII

General Linear Application (withdesign)(12hrs)

3.1 DC and AC amplifiers, AC amplifier with supply voltage 3.2 Peaking Amplifier 3.3Summing, Scaling and averaging amplifiers 3.4 Instrumentation Amplifiers using transducer bridge3.5 Differential input and differential output amplifier, Low voltage DC and AC voltmeter 3.6 Voltage to current converter with grounded load, Current to voltage converter, Very high input impedance circuit 3.7 Integratorand differentiator

Frequency Response of an Op-amp(6 hrs)

3.8 Frequency response 3.9 Compensating networks, Frequency response of internally compensated and non-compensated Op-amps 3.10 High frequency op-amp equivalent circuit 3.11 Open loop gain as a function of frequency 3.12 Closed loop frequency response 3.13 Circuit stability, Slewrate.

Text Book

Op-amps and linear integrated circuits: R.A.Gayakwad.

Unit IV

Active Filters and Oscillators (with design)(12 hrs)

4.1 Activefilters 4.1.2 Firstor derand second order low pass Butter worth filter 4.1.3 First order and second order high pass Butter worth filter 4.1.4 Wide and narrow band pass filter 4.1.5 Wide and narrow band reject filter 4.1.6 All passfilter, 4.2 Oscillators 4.2.1 Phase shift and Wienbridge oscillators 4.3 Square, triangular and saw-tooth wave generators 4.4 Voltage controlled oscillator.

Comparators and IC555 Timer (6 hrs)

4.5 Basic comparators 4.5.1 Zero crossing detector 4.5.2Schmitt Trigger 4.5.3 Comparator characteristics 4.5.4 Limitations of Op-amps & comparators

4.6 I C555 Internal architecture 4.6.1 Applications IC565PLL 4.7 Voltage regulator IC 4.7.1 Fixed Voltage regulator.

Text Book

Op-amps and linear integrated circuits: R.A.Gayakwad.

Reference Books:

1. Electronic Principles Albert P. Malvino, David J Bates, McGraw-Hill Companie
2. Introduction to Semiconductor Devices by M.S. Tyagi, John Wiley & Sons
3. Electronic Principles Albert P. Malvino, David J Bates, McGraw-Hill Companie
4. L.Floyd, Electronic Devices, “Pearson Education” New York (2004)
5. Power Electronics,V. Subrahmanyam, 2nd Edition, 2006
6. ElectronicCommunications:DennisRoddyandJohnCoolen4thEdnPearson.
7. A textbook of Applied Electronics, R.S.Sedha,S.Chand&Co.
8. Principles of Electronics, V.K.Mehta and Rohit MehtaS.Chand & Co.

PH020204: ADVANCED NUCLEAR PHYSICS

Credit-4 (54 hours)

Objective of the course: After completing this syllabus the student will (a) have an understanding of the nuclear structure and the decay processes, they will also have an understanding of different nuclear models. (b) be able to understand different nuclear interactions including fission and fusion, they will also get an idea about the recent developments in controlled fission and fusion reactions (c) have an idea about the families of elementary particles and the fundamental interactions governing them.

Unit I

Nuclear Structure and Decay (18 hrs)

1.1 Basic properties of nuclei, Masses and relative abundances 1.2 Mass defect - size and shape, nuclear binding energy 1.2.1 Nuclear stability - nuclear angular momentum and parity 1.3 Nuclear electromagnetic moments 1.3.1 Magnetic dipole moment and electric quadrapole moments 1.4 Liquid drop model – Semi empirical mass formula of Weizacker 1.5 Shell model - Shell model potential –1.5.1 Magic numbers - Valence nucleons 1.6 Beta decay - energy release 1.7 Fermi theory - experimental tests 1.7.1 Angular momentum and parity selection rules

Text Books

1. Introductory Nuclear Physics, K. S. Krane Wiley
2. Nuclear Physics, D. C. Tayal, Himalaya Publishing House
3. Nuclear Physics(2nd Edition) , S N Ghoshal, S Chand & Company

Unit II

Nuclear Interactions, Fission and Fusion (18 hrs)

2.1 Nuclear forces, Characteristics of nuclear force 2.1.1 Spin dependence, charge independence, charge symmetry 2.2 Two body problem - Ground state of deuteron
2.3 Types of nuclear reactions and conservation laws 2.3.1 Compound-nucleus reactions - heavy ion reactions 2.4 Characteristics of fission - energy in fission
2.4.1 Fission and nuclear structure 2.5 Controlled fission reactions - Fission reactors
2.6 Fusion processes, Characteristics of fusion 2.7 Controlled fusion reactor, ITER.

Text Books

1. Introductory Nuclear Physics, K. S. Krane Wiley
2. Nuclear Physics, D. C. Tayal, Himalaya Publishing House
3. Nuclear Physics(2^{nd} Edition) , S N Ghoshal, S Chand & Company

Unit III

Particle Physics (18 hrs)

3.1 Types of interactions between elementary particles 3.2 Hadrons and leptons - Masses, spin, parity and decay structure 3.3 Quark model-Confined quarks - coloured quarks, Gluons, Higg's Boson Gell-Mann- Nishijima formula 3.4 symmetries and conservation laws 3.4.1 C, P and T invariance 3.5 Applications of symmetry arguments to particle reactions 3.6 Parity non-conservation in weak interactions
3.7 Grand unified theories (Qualitative ideas), LHC (Elementary ideas).

Text Books

1. Introduction to Elementary Particle, D.J. Griffiths, Harper and Row,NY, (1987)
2. Nuclear Physics, D. C. Tayal, Himalaya Publishing House
3. Nuclear Physics(2^{nd} Edition) , S N Ghoshal, S Chand & Company

Reference Books

1. Nuclear Physics, R.R. Roy and B.P. Nigam, New Age International, New Delhi,(1983).
2. The particle Hunters - Yuval Ne'eman & Yoram kirsh CUP, (1996)
3. Concepts of Nuclear Physics, B.L. Cohen, TMH, New Delhi, (1971).
4. Theory of Nuclear Structure, M.K. Pal, East-West, Chennai, (1982).
5. Atomic Nucleus, R.D. Evans, McGraw-Hill, New York.
6. Nuclear Physics, I. Kaplan, 2nd Edn, Narosa, New Delhi, (1989).

Advanced Reading

1. Introduction to Nuclear Physics, H.A. Enge, Addison Wesley, London, (1975).
2. Introductory Nuclear Physics, Y.R. Waghmare, Oxford-IBH, New Delhi, (1981).
3. Atomic and Nuclear Physics, Ghoshal,Vol. 2, S. Chand & Company
4. Fundamentals of Elementary Particle Physics, J.M. Longo, MGH,New York, (1971).
5. Nuclear and Particle Physics, W.E. Burcham and M. Jobes, Addison-Wesley, Tokyo, (1995).

PH020205: ELECTRONICS PRACTICALS

Credit-4 (180 hours)

(Minimum of 12 Experiments should be done)

1. RC coupled CE amplifier – two stages with feedback – frequency response and voltage gain
2. Differential amplifier – using transistors – constant current source – frequency response
3. Active filters – low pass and high pass – first and second orders – frequencyresponse and roll of rate
4. Band pass filter using single op-amp
5. Voltage controlled oscillator using transistors
6. Voltage regulation using op-amp with short circuit protection
7. UJT characteristics
8. Relaxation oscillator using UJT
9. Characteristics of SCR
10. RF amplifier- frequency response and band width
11. Op-amp monostable multivibrator, square wave generator
12. IC 555 monostable multivibrator and astable multivibrator
13. IC 555 pulse width modulation and linear RAMP generator
14. Voltage controlled oscillator using IC 555
15. Shift registers Binary sequence generator
16. Synchronous counters and divide by N counters
17. Op-amp mathematical operations
    a) Summing amplifier
    b) Differential amplifier
    c) Zero Cross Detector
    d) Op-amp as an integrator and differentiator.
18. Amplitude modulation using transistors
19. AM Modulator and Demodulator using MC1496
20. Precision rectifiers – measurement of rectifier efficiency at different frequencies
21. Op- amp triangular wave generator with specified amplitude
22. Op- amp sawtooth wave generator with specified amplitude

23. Analog to digital and digital to analog converter ADC0800 & DAC0800
24. RC phase shift Oscillator using op amp
25. Op-amp Wein bridge oscillator
26. Crystal Oscillator
27. Single stage CE amplifier design and study of frequency response.
28. Study of RC Phase shift Oscillator using transistors.
29. Study of Schmitt Trigger Circuits and calculation of Hysteresis voltage.
30. Emitter follower and Source follower circuits.
31. Frequency multiplier using PLL

SEMESTER – III

PH020301: STATISTICAL PHYSICS AND ASTROPHYSICS

Credit-4 (72 hours)

Objective of the course: The course is designed to give the students a firm understanding of statistical mechanics. The concept developed in classical system for various ensembles when applied to quantum systems have certain limitations, but classical results can be recovered from the quantum theories in the high temperature-low density limit. The theories deduced by Statistical Mechanics have been applied to Astro Physics. A fundamental study of Astro Physics along with structure and evolution of stars have been covered in this course.

Unit I

Quantum Statistical Mechanics and Ideal Gas Systems (18 hrs)

1.1 The postulates of Quantum statistical mechanics – in distinguishability of particles - exchange degeneracy 1.2 Density matrix - Ensembles in Quantum statistical mechanics - statistical distribution – The ideal gas in quantum mechanical micro canonical and other quantum mechanical ensemble 1.3 Partition functions and other thermodynamic quantities of monatomic and diatomic molecules 1.4 Thermodynamic behaviour of an ideal Fermi gas– Pauli Para magnetism 1.5 Thermodynamic behavior of a Bose gas – Bose Einstein condensation – 1.6 Theory of white dwarf stars.

Text books

1. Statistical Mechanics, Gupta, Kumar, Pragati Prakasan
2. Statistical mechanics, Kerson Huang, John Wiley and Sons

Unit II

The Canonical and Grand Canonical Ensemble Fluctuations and Phase Transitions (18 hrs)

2.1 Thermo dynamical relations in a canonical ensemble– energy fluctuations in the canonical ensemble:correspondence with micro canonical ensemble 2.2 Density and energy fluctuations in the grand canonical ensemble: correspondence with other ensembles.2.3 One dimensional random walk problem – Brownian motion and Random walk- 2.4.Fokker Planck equation Phase transitions – First and second order phase transition correlation functions 2.5 Bragg–Williams approximation – critical phenomena - critical exponents - scaling hypothesis2.6 Ising model and its solution for a linear chain –2.7 Equivalence of Ising model to other models - lattice gas and binary alloy- solution of one dimensional Ising model 2.8 Liquid Helium

Text books

1. Statistical mechanics, R..K. Pathria, Butterworth-Heinemann
2. Statistical Mechanics, B.K. Agarwal and M. Eisner, Wiley Eastern

UNIT III

Astrophysics (18hrs)

3.1 The sun-internal structure-solar atmosphere-sun spots-solar flares-prominences

3.2 celestial coordinate system-sun earth system –galactic system 3.3 Stellar spectrum - stellar types -Stellar magnitude sequence-Absolute magnitude and the distance modulus- Colour index of a star -Luminosities of a star 3.4 Measurement of distances and Absolute luminosities 3.5 measuring temperature- Application of Saha's Equation. 3.6 Virial theorem3.7 stellar energy -Thermonuclear reactions in stars, pp chains and CNO cycle-Solar Neutrino problem- subsequent thermonuclear reactions nucleosynthesis

Text books

1 Astrophysics: Stars and Galaxies, K D Abhyenkar, Universities Press.

2 Introduction to Astrophysics, Baidyanath Basu, PHI.

3 Textbook of astronomy an astrophysics with elements of cosmology, V.B.Bhatia, Narosa publishing house, 2001

UNIT IV

Structure and Evolution of Stars (18hrs)

4.1 Evolution of a star-Hertz Sprung Russell diagram4.2 star formation - life of a star - stellar structure -final stages of stellar evolution 4.3 Newtonian theory of stellar equilibrium4.4 White Dwarfs, Electron degeneracy and equation of States-Chandrasekhar Limit-Mass- Radius relation of WD4.5 Neutron Stars, Mass-Radius relations of NS-Pulsars, Magnetars, Gamma ray bursts4.6 Black holes, Collapse to a black hole, event horizon, singularity. 4.7 Qualitative discussions on galaxies, Nebulae, Quasars, Brown Dwarfs, Red giants, Nova, supernova.

Text books

1 Astrophysics: Stars and Galaxies, K D Abhyenkar, Universities Press.
2 Introduction to Astrophysics, Baidyanath Basu, PHI.

Reference Books:

1. Fundamentals of Statistical Mechanics, B. B. Laud, New Age International.
2. Elements of Statistical Mechanic, Kamal Singh, S P. Singh, S. Chand & Co.
3. Introduction to Statistical Mechanics, S.K. Sinha, Alpha Science International.
4. Statistical Mechanics, Tung Tsang, Rinton Press.
5. Introductory Statistical Mechanics, R. Bowley & M. Sanchez, 2nd Edn. Oxford University Press
6.The Structure of the Universe – J.V.Narlikar (OUP, 1978)
7.Fundamental Astronomy. H. Karttunen.P. Kröger.H. Oja.M. Poutanen .K. J. Donner (Eds.),Springer-Verlag Berlin Heidelberg New York
8.The Physical Universe. FrankShu. University Science Books
9.An Introduction to Modern Astrophysics. B.W. Carroll, D.A.Ostlie, Pearson

PH020302: NUMERICAL METHODS IN PHYSICS

Credit-4 (72 hours)

Objective of the course : Apply numerical methods to obtain approximate solutions to mathematical problems. Derive numerical methods for various mathematical operations and tasks, such as interpolation, curve fitting, differentiation, integration, the solution of system of equations, the solution of ordinary and partial differential equations and to learn how to apply numerical methods to a variety of physical problems.

Unit I

Interpolation (12 hrs)

1.1 Finite differences 1.1.1Forward differences - Backward differences – Central differences 1.1.2 Introduction to finite difference operators1.1.3 Detection of errors by use of difference tables1.1.4. Differences of a polynomial 1.2 Interpolation - Errors in Polynomial Interpolation 1.2.1 Newton’s formulae for interpolation – forward and backward interpolation formula 1.2.2 Central difference interpolation formulae - Gauss central difference formulae - Stirlings formulae-Evretts formula 1.2.3 Interpolation with unevenly spaced points-Lagrange’s interpolation formulae- Error in Lagrange’s interpolation formulae - Hermite’s interpolation formulae

Text Books

1. Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd. .(Fifth Edition) Chapter – 3
2. Numerical methods for Scientists and Engineers – K Sankara Rao, PHI Learning Private Limited.(Third Edition) Chapter - 6
3. Numerical Methods in Engineering & Science – Dr. B S Grewal, Khanna Publishers (10^{th} Edition) Chapters – 6,7

Curve fitting (6 hrs)

1.3Least Squares Curve fitting procedures 1.3.1 Fitting a straight line 1.3.2 Linearization of Nonlinear laws - Curve fitting by polynomial.

Text Books

1. Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd.(Fifth Edition) Chapter – 4
2. Numerical methods for Scientists and Engineers – K Sankara Rao, PHI Learning Private Limited.(Third Edition) Chapter - 5
3. Numerical Methods in Engineering & Science – Dr. B S Grewal, Khanna Publishers (10^{th} Edition) Chapter – 5

Unit II

Numerical Differentiation (6 hrs)

2.1 Numerical differentiation 2.1.1Differentiation for tabular and non-tabular functions 2.1.2 Errors in Numerical differentiation 2.1.3finding maxima and minima of a tabulated function

Numerical Integration (10 hrs)

2.2 Numerical integration 2.2.1 Trapezoidal rule – error associated 2.2.2 Simpson's 1/3 rule – error associated 2.2.3 Simpson's 3/8 rule –error associated 2.3 Romberg Integration 2.4 Gaussian Integration 2.5 Double Integration 2.6 Monte Carlo evaluation of integrals –Newton – cotes integration formula

Text Books

1. Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd.(Fifth Edition) Chapter – 6
2. Numerical methods for Scientists and Engineers – K Sankara Rao, PHI Learning Private Limited.(Third Edition) Chapter - 7
3. Numerical Methods in Engineering & Science – Dr. B S Grewal, Khanna Publishers (10^{th} Edition) Chapter – 8

Unit III

Numerical Solution of Ordinary Differential Equations (10 hrs)

3.1 Euler method 3.2 modified Euler method and Runge - Kutta 4th order methods - adaptive step size R-K method 3.3 predictor - corrector methods - Milne's method, Adam - Mouton method.

Text Books

1. Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd. .(Fifth Edition) Chapter – 8
2. Numerical methods for Scientists and Engineers – K Sankara Rao, PHI Learning Private Limited.(Third Edition) Chapter - 8
3. Numerical Methods in Engineering & Science – Dr. B S Grewal, Khanna Publishers (10^{th} Edition) Chapter – 10

Numerical Solution of System of Equations (10 hrs)

3.2 Gauss-Jordan elimination Method 3.3 Gauss-Seidel iteration method 3.4 Gauss elimination method 3.5 Gauss-Jordan method to find inverse of a matrix. 3.6 Power method and Jacobi's method to solve eigen value problems.

Text Books

1. Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd.(Fifth Edition) Chapter –7
2. Numerical methods for Scientists and Engineers – K Sankara Rao, PHI Learning Private Limited.(Third Edition) Chapter - 3
3. Numerical Methods in Engineering & Science – Dr. B S Grewal, Khanna Publishers (10^{th} Edition) Chapter – 3

Unit IV

Numerical Solutions of partial differential equations (18 hrs)

4.1 Boundary value problem and initial value problem - Cauchy’s and Dirichlet conditions – Classification of partial differential equation 4.2 Finite difference approximations to derivatives 4.3 Laplace equation 4.3.1 Iterative methods -Jacobi’s method – Gauss Seidal method – Successive over relaxation- The ADI method

4.4 Parabolic equations – Heat conduction equation 4.4.1 Iterative methods for the solution of equations 4.5 Hyperbolic equations – Wave equations -Schmidt method – Crank – Nicolson method

Text Books

1. Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd.(Fifth Edition) Chapter –9
2. Numerical methods for Scientists and Engineers – K Sankara Rao, PHI Learning Private Limited.(Third Edition) Chapter - 9

3. Numerical Methods in Engineering & Science – Dr. B S Grewal, Khanna Publishers (10th Edition) Chapter – 11

Reference Books:

1. Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd.(Fifth Edition)
2. Numerical methods for Scientists and Engineers – K Sankara Rao, PHI Learning Private Limited.(Third Edition)
3. Numerical Methods in Engineering & Science – Dr. B S Grewal, Khanna Publishers (10th Edition)
4. An Introduction to Computational Physics, Tao Pang, Cambridge University Press
5. Numerical methods for scientific and Engineering computation M.KJain,S.R.K Iyengar, R.K. Jain, New Age International Publishers
6. Computer Oriented Numerical Methods, V. Rajaraman, PHI, 2004.
7. Numerical Methods, E. Balagurusami, Tata McGraw Hill, 2009.
8. Numerical Mathematical Analysis, J.B. Scarborough, 4th Edn, 1958
9. Mathematical Methods, G. Shanker Rao, K. Keshava Reddy, I.K. InternationalPublishing House, Pvt. Ltd.

PH020303: ADVANCED QUANTUM MECHANICS

Credit-4 (72 hours)

Objective of the course: After studying the course, the student will (i) understand the fundamentals of time dependent perturbation theory and different types of approximations used,(ii) understand the concepts of scattering and be able to apply them to various problems,(iii) the concepts of relativistic quantum mechanics and its applications,(iv) understand not only the concept of classical and quantum field theories but also be able to quantize scalar and vector fields.

Unit I

Time Dependent Perturbation Theory (12 hrs)

1.1 Time dependent potentials 1.1.1 Interaction picture -Comparison of pictures - Time evolution operator in interaction picture 1.2 Time dependent perturbation theory

- Dyson series – transition probability 1.2.1 Constant perturbation – Fermi's Golden rule 1.2.2 Harmonic perturbation - interaction with classical radiation field - Transition rates for absorption and emission of radiation1.2.3 Electric dipole approximation - Electric dipole selection rules1.3 Photo electric effect – Energy shift and decay width.

Text Book

1. Modern Quantum Mechanics, J.J. Sakurai, Revised Edition (Chapter 5)

Approximation Methods(4 hrs)

1.4 Sudden approximation-Sudden reversal of magnetic field 1.5 Adiabatic approximation -Adiabatic reversal of magnetic field.

Text Book

1. Quantum mechanics – V. K. Thankappan New Age Int. Pub 1996 (Chapter 8)

Unit II

Scattering (18 hrs)

2.1 Asymptotic equation for scattering 2.1.1 Scattering Amplitude and Differential Cross Section 2.2 The Born Approximation2.2.1 Yukawa potential- Rutherford Scattering2.3 Validity of the Born Approximation, Optical theorem 2.4 Method of Partial waves-Scattering by a perfectly rigid sphere2.5 Scattering by a square well potential - scattering length2.6 Ramsauer-Townsend effect, Resonance scattering-Breit-Wigner formula.

Text Books

1. A modern approach to Quantum Mechanics, Townsend.
2. Modern Quantum Mechanics, J.J. Sakurai, Revised Edition.

Unit III

Introduction to Relativistic Quantum Mechanics (18 hrs)

3.1 Klein-Gordon equation-plane wave solutions 3.1.1 Interpretation -Probability conservation 3.1.2 Covariant notation 3.2 Derivation of Dirac equation 3.2.1 conserved current representation - large and small components 3.3 Approximate Hamiltonian for electrostatic problem 3.4 Free particle at rest -plane wave solutions -

gamma matrices 3.5 Relativistic covariance of Dirac equation 3.6 Angular momentum as constant of motion.

Text Book

1. Advanced Quantum Mechanics, J.J. Sakurai, Pearson Education (Chapter 3)

Unit IV

Classical Field Theory (8 hrs)

4.1 Euler-Lagrange equation for fields 4.2 Hamiltonian formulation – functional derivatives 4.3 Conservation laws for classical field theory - Noether's theorem

Non-Relativistic Quantum Field Theory(12 hrs)

4.4 Quantization rules for Bose particles, Fermi particles - relativistic quantum field theory4.5 Quantization of neutral Klein Gordon field 4.6 Canonical quantization of Dirac field 4.6.1 Plane wave expansion of field operator 4.6.2 Positive definite Hamiltonian

Text Book

1. Field Quantization, W Greiner , J Reinhardt, Springer, (Chapter 2, 3,4 & 5)
2. Quantum mechanics - V.K. Thankappan, New Age Int. Publishers

Reference Books:

1. Quantum Field Theory, Lewis H. Ryder, Academic Publishers, Calcutta,1989
2. Quantum Field Theory, Claude Itzykson& Jean Bernard Zuber, MGH, 1986
3. Introduction to Quantum Field Theory, S.J. Chang, World Scientific, 1990
4. Quantum Field Theory, Franz Mandl& Graham. Shaw, Wiley 1990

PH020304: COMPUTATIONAL AND ELECTRONICS PRACTICALS

Credit-5 (180 hours)

(Minimum of 12 Experiments should be done)

(Experiments from 1 to 15 are C++ programs)

1. Motion of a spherical body in a viscous medium
2. Projectile motion and motion of a satellite
3. SHM – damped and forced oscillations
4. Formation of standing waves
5. Young's double slit – interference
6. Diffraction due to a grating
7. Polarisation and birefringence
8. Electric field due to a point charge and equi-potential surface
9.Motion in electric and magnetic fields – cyclotron
10.Solution of a differential equation – Runge kutta method
11. The variation of magnetic field with critical temperature in superconductivity
12. Finding the roots of a non-linear equation by bisection method
13. Solution of non linear differential equation - Bisection method
14.Numerical integration - rectangular method
15.Numerical integration - Simpson's rule
16. Microprocessor (use a PC or 8086-µp kit) – Find the largest and smallest of numbers in array of memory.
17. Microprocessor (use a PC or 8086-µp kit)– Sorting of data in ascending and descendingorder
18. Microprocessor (use a PC or 8086-µp kit)– Measurement of Multi channel analog voltageusing AC cards.
19. Microprocessor (use a PC or 8086-µp kit) – Conversion of Hexadecimal number to ASCII and vice versa.
20. Design and construct a RF oscillator using transistor. Measure the frequency and compare it with the designed value. Repeat the same for at least two capacitors.
21. Design and construct a pulse width modulator using IC 741.
22. Design and construct a full wave controlled rectifier using IC 2P4M.

23. Generation of Frequency modulation using IC555 timer. Confirm the modulation index and repeat the experiment for minimum three input signal voltages.
24. Design and generation of Inverting and difference amplifiers using OP AMP
25. Generation of low distortion sine wave using OP AMP.
26. Design and construct a 4-bit binary synchronous counter using JK flipflops also constructthe up counter/a down counter.
27. Design and construct a shift register using JK flipflops.
28. Design and construct a pulse amplitude modulator. Measure its output wave form.
29. To study Ripple Counter using Flip flops.
30. Design and setup half adder and full adder circuits and verify the truth tables (a) using X- OR and NAND gates (b) using NAND gates alone.
31. Design and construct Instrumentation amplifier using a transducer
32. Frequency modulation and demodulation using IC –CD4046.
33. FET: Study of static drain characteristics and calculations of various parameters
34. Study of Multiplexer and Demultiplexer IC.

SEMESTER – IV

PH020401: ATOMIC AND MOLECULAR SPECTROSCOPY

Credit-4 (90 hours)

Objective of the course: Objective of the course is to learn atomic, molecular and spin resonance spectroscopy. At the end of the course, the leaner will able to (i) describe the atomic spectra and change in behaviour of atom in external applied electric and magnetic field (ii) explain rotational, vibrational, electronic and Raman spectra of molecules (iii) describe electron spin and nuclear magnetic resonance spectroscopy and their applications**.**

Unit I

Atomic Spectra (18 hrs)

1.1 Vector atom model-electron spin- Stern-Gerlach experiment 1.2 LS and jj coupling schemes-spectroscopic terms-Pauli's exclusion principle1.3Spin-orbit interaction-interaction energy-interaction energy in LS and jj coupling schemes 1.4 Selection rule-Hund's rule-Lande interval rule 1.5 Normal and anomalous Zeeman effect -Paschen-Back effect 1.6 Stark effect in one electron systems-hyperfine structure-width of spectral lines.

Text Books

1. Atomic and Molecular Spectra: Laser – Raj Kumar
2. Spectroscopy (Vol. 2 & 3), B.P. Straughan & S. Walker, Science paperbacks 1976

Unit II

Resonance Spectroscopy (18 hrs)

2.1 ESR-Theory- Relaxation process- g factor- Experimental setup -Hyperfine structure applications 2.2 NMR- Theory -Relaxation process-Experimental technique-Chemical shift- Spin-spin coupling-applications. 2.3 Mössbauer effect-Theory-Experimental technique- Chemical isomer shift magnetic hyperfine interactions- Electric quadrupole interaction-applications

Text Book

1. Fundamentals of molecular spectroscopy – Colin N Banwell and Elaine M .McCash

Unit III

Microwave Spectroscopy (18 hrs)

3.1 Classification of molecules- Rotational spectra of rigid diatomic moleculesExample of $CO_2$3.2 Isotopic effect-intensity of rotational lines- Non rigid rotator- Example of HF 3.3 Linear polyatomic molecules-symmetric top molecules
3.4 Microwave spectrometer-information derived from rotational spectra. 3.5 Infrared Spectroscopy -Vibrational energy of anharmonic oscillator -Diatomic vibrating rotator- Morse curve –IR spectra – Spectral transitions and selection rule 3.6. Breakdown of Born - Openheimer approximation - vibrational spectra of polyatomic molecules3.7 Normal modes of vibration of H_2O and CO_2 - overtones and combinations - Influence of rotation on the spectra of linear and symmetric top molecules 3.8 IR spectroscopic analysis - FT-IR spectroscopy

Text Book

1. Fundamentals of molecular spectroscopy – Colin N Banwell and Elaine M .McCash

Unit IV

Raman Spectroscopy (18hrs)

4.1 Raman effect- theory 4.2 Rotational Raman spectra-linear molecules-symmetric top molecules 4.3 Vibrational Raman spectra-rotational fine structure 4.4 Raman activity-mutual exclusion principle 4.5 Structure determination using Raman and IR spectroscopy 4.5.1 Laser Raman spectrometer-Techniques and instrumentation Near Infra red FT Raman spectroscopy 4.6 Hyper Raman Effect-classical treatment and experimental techniques 4.7Stimulated ,Inverse, coherent Antistokes and Photoacoustic Raman scattering.

Unit V

Electronic Spectroscopy (18hrs)

5.1 Electronic spectra of diatomic molecules- progressions and sequences 5.2 Frank Condon principle- rotational fine structure of electronic vibration spectra 5.3 Fortrat parabola - dissociation- pre dissociation 5.4 Fluorescence and phosphorescence - Photoelectron spectroscopy-principle instrumentation 5.5 Informations from Photoelectron spectra- Auger electron spectroscopy-X Ray Fluorescence.

Text Book

1. Molecular structure and spectroscopy, G. Aruldhas, PHI.

Reference Books:

1. Introduction of Atomic Spectra, H.E. White, Mc Graw Hill
2. Raman Spectroscopy, D.A. Long, Mc Graw Hill international, 1977
3. Introduction to Molecular Spectroscopy, G.M. Barrow, Mc Graw Hill
4. Molecular Spectra and Molecular Structure, Vol. 1, 2 & 3. G. Herzberg, Van Nostard, London.
5. Elements of Spectroscopy, Gupta, Kumar & Sharma, Pragathi Prakshan
6. The Infra Red Spectra of Complex Molecules, L.J. Bellamy, Chapman & Hall.Vol. 1 & 2.
7. Laser Spectroscopy techniques and applications, E.R. Menzel, CRC Press, India.

ELECTIVES

BUNCH-A: MATERIAL SCIENCE-I SPECIALIZATION

PH840301: THIN FILM SCIENCE AND CRYSTAL GROWTH TECHNIQUES

Credit-3 (54 hours)

Objective of the course: At the end of this course student will be able to : i) Have the basic knowledge about the physics behind thin film and crystal growth mechanism ii) Have the understanding of vacuum techniques used for thin film growth iii) Have the knowledge about characterization methods and application of thin films iv) Have the basic theory of crystal growth v) Have the understanding of a variety of crystal growth mechanism vi) Have the understanding of thin film and crystal growth preparation techniques

UNIT I

Thin Film (18 hrs)

1.1 Nucleationof thin films – Langmuir theory of condensation 1.2 Theories of nucleation – Liquid like coalescence and growth process – Epitaxial growth

1.2 Vacuum pumps and gauges– Exhaust pumps-rotary oil pump-molecular pump-diffusion pumps-Pirani gauge-penning gauge 1.4 Thickness measurement – optical methods-thickness monitor method 1.5 Properties of thin films- Morphological and structural properties-electrical and optical and properties 1.6 Applications of thin films- thin film as protective coating-thin film photovoltaic cells-thin film batteries-discrete resistive components

Text books

1. Thin film phenomena, K.L Chopra, McGraw Hill, New York
2. Thin film fundamentals, A. Goswami, New Age International

UNIT II

Crystal Growth from Melt and Solution Growth (20 hrs)

2.1 Growth techniques- from the melt - the Bridgmann technique – crystal pulling

2.2 Czocharalski method- experimental set up - controlling parameters advantages and disadvantages. 2.3 Convection in melts – liquid solid interface shape - crystal growth by zone melting 2.4 Verneuil's flame fusion technique. Low temperature solution growth 2.5 Methods of crystallization - slow cooling, solvent evaporation, temperature gradientmethods

Text book

1. P. SanthanaRagavan and P. Ramasamy, Crystal Growth Processes and Methods, KRU Publications, Kumbakonam (2001)

UNIT III

Deposition Techniques (16 hrs)

3.1 Physical vapour deposition – Resistive heating-flash evaporation-arc evaporation-exploding wire technique-electrode beam heating 3.2 Chemical vapour deposition (CVD)- pyrolysis, hydrogen reduction mechanism, polymerization3.3 Cathodic sputtering-glow discharge sputtering, low pressure sputtering, AC and Dc Magnetron sputtering3.4 Sol Gel method- Dip coating -Spin coating method3.5 Pulse laser deposition technique- hydrothermal growth.

Text books

1. Thin film phenomena, K.L Chopra, McGraw Hill, New York
2. Vacuum deposition of Thin films, L. Holland, Chapman Hall, London

Reference Books:

1.J.C. Brice, Crystal Growth Processes, John Wiley and Sons, New York (1986)

2.Handbook of thin film Technology, L.I Maissel and R Glang, McGraw Hill

3. Thinfilm deposition: Principles and practice-Donald.L. Smith
4. Materialscience of thinfilms-Milton Ohring
5. Optical Properties of Thin Films, O. S. Heaven, Dover Publications
6. Crystallography for Solid State Physics: Verma & Shrivastava

PH840402: NANOSCIENCE AND NANOTECHNOLOGY

Credit-3 (90 Hours)

Objective of the course: On successful completion of the course the students will be able to understand the synthesis and properties of the nanoparticles, Distinguish the functionality of nanomaterial and their structural characteristics, Have an idea about nano electronics, Nanomagnetiam and different carbon based nanostructures .

Unit I

Introduction to Nanoscience& Synthesis of Nanomaterials (18 hrs)

1.1Definition of nanotechnology, Current technologies and problem, Nano the Beginning 1.2 Nano and energetics, Nano and implication 1.3 General issues of concern of Synthesis of Nanomaterial 1.4 Synthetic methods: the common issue of concern 1.5 Variety in nanomaterials, Microemulsion based methods for nanomaterial 1.6 Solvothermal synthesis 1.7synthesis using support, using biology
1.8 Inert gas condensation.

Text book

1.A textbook of nanoscience and nanotechnology, T. Pradeep, Tata McGraw-Hill Education.

Unit II

Theoretical understanding and PropertiesofIndividualNanoparticles (18 hrs)

2.1Quantum mechanics of low dimensional systems 2.2 Exciton confinement in quantum dots 2.3 Quantum mechanics of confined nanoclusters 2.4 Band Gap engineering and optical response 2.5 Metal Nanoclusters :Magicnumbers , Geometric Structure, Electronic Structure, Reactivity, Fluctuations, Magnetic Clusters Bulk to Nanotransition2.6 Semiconducting Nanoparticles: Optical Properties, Photofragmentation , Coulombic Explosion 2.7 Rare Gas and Molecular Clusters: Inert-Gas Clusters, Superfluid Clusters

Text books

1. Introduction to Nanotechnology - Charles P. Poole Jr. and Franks. J. Qwens
2. A textbook of nanoscience and nanotechnology, T. Pradeep, Tata McGraw-Hill Education.

Unit III

Structural Characterization of Nanomaterials(18 hrs)

3.1 Scanning Electron Microscopy (SEM) 3.2 Transmission Electron Microscopy (TEM), Environmental TEM, Scanning Transmission electron Microscopy (STEM), 3.3 In situ nano measurements, EELS 3.4 Electron Diffraction as Tool 3.5 Scanning Tunnelling Microscopy (STM) 3.6 Atomic Force Microscopy 3.7 Confocal Microscopy, Scanning near field optical microscopy (SNOM). 3.8 X-ray diffraction (XRD), Small angle X-ray scattering (SAXS)

Text book

1. A textbook of nanoscience and nanotechnology, T. Pradeep, Tata McGraw-Hill Education.

Unit-IV

Carbon Nano structures& Special Nanomaterials(18 hrs)

4.1. Carbon fullerenes, Fullerene-derived crystals, Carbon nanotubes 4.2. Micro and Mesoporous Materials:Ordered mesoporous structures, Random mesoporous structures, Crystallinemicroporous materials: zeolites 4.3Core-Shell Structures: Metal-oxide structures, Metal-polymer structures, Oxide-polymer structures 4.4 Organic-Inorganic Hybrids: Class I hybrids, Class I1 hybrids 4.5. Intercalation Compounds 4.6 Nanocomposites and Nanograined Materials.

Text book

1. Nanostructures and Nanomaterials - Synthesis, Properties and Applications – Guozhong Cao, Imperial college press

Unit V

Molecular electronics, Nanolithography, Nanomagnetiam (18 hrs)

5.1 Molecules and experimental advance 5.2 Mechanism of molecular transport and advanced application 5.3 Lithography Concepts and definition 5.4 Photolithography,

scanning probe lithography, soft lithography 5.5 Nano manipulation5.6 Basics of magnetisam, magnetic nanostructures 5.7 Magnetisam of nanosized materials
5.8 Application of nanomagnetic materials

Text book

1.A textbook of nanoscience and nanotechnology, T. Pradeep, Tata McGraw-Hill Education.

Reference Books: .

1. Introduction to nanoscience and nanotechnology. Chris Binns,. John Wiley & Sons
2. Basic Principles of Nanotechnology, By Wesley C. Sanders, CRC Press
3. Textbook of nanoscience and nanotechnology. B. S. Murty, Springer
4. Handbook of microscopy for nanotechnology. Nan Yao, Lin Wang Zhong, Kluwer academic publishers.
5. Nano: the essentials.T. Pradeep, Tata McGraw-Hill Education.
6. Fundamentals of nanotechnology, G. L Hornyak, H. F. Tibbals, J. Dutta, & , J. J Moore. CRC press.
7. Introduction to Nanoscience, Gabor L. Hornyak, Joydeep Dutta, H.F. Tibbals, Anil Rao, CRC Press
8. Handbook of Nano Physics Nanoparticles and Quantum Dots Klaus D Sattler CRC Press Taylor and Francis Group

PH840403: MATERIALS SCIENCE AND ENGINEERING

Credit - 3(90 Hours)

Objective of the course: The course is primarily designed for Material science students. Therefore, focus of the course is on structural materials. The course is hoping to address both theoretical and practical aspects of materials science and engineering. To serve this purpose, the course is divided into five different units. a) Bonding in materials, b) imperfections and diffusion mechanism c) Polymer structure, d) Mechanical properties and e) different Types and Applications of Materials.

Unit I

Atomic Structure and Interatomic Bonding in materials (18 hrs)

1.1 Historical Perspective of Materials Science 1.2 Classification of Materials - Fundamental Concepts of Electrons in Atoms -The Periodic Table 1.3 Atomic Bonding In Solids : Bonding Forces and Energies 1.4 Primary Interatomic Bonds: Ionic Bonding, Covalent Bonding, Metallic Bonding 1.5 Secondary Bonding or Van der Waals Bonding 1.6 Molecules- Crystal Structures: Fundamental Concepts, Unit Cells 1.7 Metallic Crystal Structures.

Text book

1. Fundamentals of Materials Science and Engineering: An Interactive e.Text, 5th Edition by William D. Callister and William D. Callister Jr. Wiley

Unit II

Imperfections and Diffusion in solids(18 hrs)

2.1 Point Defects in Metals - Point Defects in Ceramics 2.2 Impurities in Solids
2.3 Specification of Composition 2.4 Dislocations—Linear Defects -Interfacial Defects 2.5 Grain size Determination 2.6 Diffusion Mechanisms- Steady-State Diffusion , Nonsteady-State Diffusion 2.7 Factors That Influence Diffusion

Text book

1. Fundamentals of Materials Science and Engineering: An Interactive e.Text, 5th Edition by William D. Callister and William D. Callister Jr. Wiley

Unit III

Polymer Structures (18 hrs)

3.1 Hydrocarbon Molecules -Polymer Molecules -The Chemistry of Polymer Molecules 3.2 Molecular Weight, Shape and Structure 3.3 Molecular Configurations 3.4 Thermoplastic and Thermosetting Polymers- Copolymers 3.5 Polymer Crystallinity -Polymer Crystals

Text book

1. Fundamentals of Materials Science and Engineering: An Interactive e.Text, 5th Edition by William D. Callister and William D. Callister Jr. Wiley

Unit IV

Mechanical Properties (18 hrs)

4.1 Concepts of Stress and Strain 4.2 Elastic Deformation: Stress–Strain Behavior, Anelasticity 4.3 Elastic Properties of Materials 4.4 Mechanical behavior of metals: Tensile Properties, True Stress and Strain -Compressive, Shear and Torsional deformation 4.5Mechanical behavior of ceramics: Flexural Strength, Elastic Behavior 4.6Mechanical behavior of Polymers: Stress–Strain Behavior, Macroscopic Deformation – Hardness and other mechanical property considerations - Tear strength and hardness of polymers 4.7 Property variability and design/safety factors

Text book

1. Fundamentals of Materials Science and Engineering: An Interactive e.Text, 5th Edition by William D. Callister and William D. Callister Jr. Wiley

UnitV

Types and Applications of Materials (18 hrs)

5.1 Ferrous Alloys 5.2 Nonferrous Alloys 5.3 Types of ceramics: Glasses,Glass–Ceramics, Clay Products 5.4Refractories, Abrasives, Cements 5.5 Advanced Ceramics, Diamond and Graphite5.6 Types of polymers: Plastics, Elastomers, Fibers,Miscellaneous Applications5.7 Recycling issues in materials science and engineering

Text book

1. Fundamentals of Materials Science and Engineering: An Interactive e.Text, 5th Edition by William D. Callister and William D. Callister Jr. Wiley

References Books:

1. An Introduction to Materials Engineering and Science for Chemical and Materials Engineers: Brian S. Mitchell, Wiley
2. Materials Science and Engineering an Introduction, W. D. Callister, Jr., John, Wiley
3. Materials Science and Engineering A First Course 5 ed., V. Raghavan, Prentice Hall of India Pvt. Ltd.
4. Materials: Introduction and Applications, Witold Brostow and Haley E. Hagg Lobland, Wiley
5. Material science and Processses, A.K Hajara Choudhury, Indian Book Distributing Co

PH840404: MATERIAL SCIENCE PRACTICALS

Credit-5 (180 hours)

(Minimum of 12 Experiments should be done)

Section A

GENERAL MATERIAL SCIENCE EXPERIMENTS

1. Study the resistivity of a single crystal by four probe method at constant deviation of temperature and find the energy gap of the material.
2. Compare the capacitance of a ceramic and a polymer capacitance with temperature. Show that the dielectric constant of the ferroelectric material used in the ceramic capacitor follows Curie-Weiss law.
3. Study the variation of voltage with respect to temperature for a semiconducting material and determine the bandgap energy
4. Using hall effect set up, determine (a) Hall coefficient (b) Mobility of charge carriers (c) Carrier concentration.
5. Observe Zeeman effect and measure the shift of atomic energy levels in an external magnetic field.
6. Determine the absolute Seebeck co-efficient of copper and constantan as a function of temperature.
7. Study the para to ferroelectric transition in barium titanate and determine the Curie temperature.
8. Determine the young's modulus of a metal using strain gauge apparatus.
9. Study the variation in electrical conductivity with temperature of NaCl / KCl and determine the vacancy migration energy and formation energy of vacancy pairs.
10. Measure the absolute Seebeck coefficient of n-type and p-type Bismuth telluride.
11. Determine the Fermi energy and Fermi temperature of copper using CF bridge by measuring its temperature coefficient of resistance.
12. Ultrasonic Interferometer – ultrasonic velocity in liquids
13. Ultrasonic Interferometer – Young’s modulus and elastic constant of solids

Section B

ADVANCED MATERIALS EXPERIMENTS

1. Study the dependence of Hall coefficient on temperature and nature of majority charge carriers using Hall effect set-up.
2. Determine the Lande g-factor of electron using an ESR spectrometer
3. Determination of lattice constant of a cubic crystal with accuracy and indexing the Bragg reflections in a powder X-ray photograph of a crystal.
4. Determine the dipole moment of an organic molecule using a cylindrical capacitor.
5. Crystal growth-Slow evaporation technique- Determination of saturation coefficient and linear density
6. Synthesis of nano particle by Sol-gel method
7. Preparation of glassy materials using Solgel technique
8. Thin film fabrication using dip coating technique and its thickness measurements
9. Preparation of nano colloids by varying PH scale using chemical synthesis
10. Morphological analysis of nano particles using simulation technique and Sherrer equation
11. Electrical conductivity of electrolytes using conductivity meter and its PH measurements
12. Study the dielectric measurements of a material as a function of frequency using LCR Q-Meter.
13. Compare the optical absorption spectrum of a direct and an indirect bandgap semiconductor specimen using simulation technique and estimate the bandgap in each case.

Section C

OPTICS AND LASER PHYSICS EXPERIMENTS

1. Study the photo conductivity characteristics of a semiconducting material with the variation in light intensity.
2. Study the beam profile and determine the spot size of diode laser.
3. Verify Malu's law of polarization using laser.
4. Measure the coefficient of linear expansion of a solid by Fizeau's interferometer configuration.
5. Determination of the distance between the grooves of a Compact and Digital

versatile Disk using laser beam.

6. Compare the optical absorption spectrum of a direct and an indirect bandgap semiconductor specimen and estimate the bandgap in each case.
7. Determination of wavelength of an unknown light source using a compact disk.
8. Measurement of absorption coefficient of a given material using laser light.
9. Determination of Numerical aperture of an optical fibre
10. Determination of least count of the given meter scale using laser.
11. Determination particle size of given sample using a laser beam.
12. Determination of characteristics of a solar cell.
13. To study the photoelectric effect and determination of Plank's constant using LED.

BUNCH-B: MATERIAL SCIENCE-II SPECIALIZATION

PH850301: OPTOELECTRONICS

Credit -3 (54 Hours)

Objective of the course: The course is an introduction to the fundamentals of optoelectronics and principals of the optoelectronics devices. This course gives the students to acquire knowledge in the field of fibre optics technology. This course also provides the background in optoelectronics helps students to meet the demand of growing semiconductor optoelectronic industry and prepares them to advance study and research in the semiconductor optics and optoelectronic devices.

Unit I

Light emitting diode and Fibre Optics (18 hrs)

1.1Direct and indirect bandgap semiconductors, pn junction under forward and reverse bias 1.2 light emitting diodes, principle, device structures 1.3 LED materials, heterojunction high intensity LEDs 1.4 double heterostructure, LED characteristics and LEDs for optical fiber communications, surface and edge emitting LEDs. 1.5 Symmetric planar dielectric slab waveguide, waveguide condition, single and multimode waveguides 1.6 TE and TM modes, modal and waveguide dispersion in the planar waveguide, dispersion diagram, intermodal dispersion, intramodal dispersion, dispersion in single mode fibers, material dispersion, waveguide dispersion1.7 chromatic dispersion, profile and polarization dispersion, dispersion flattened fibers, bit rate and dispersion1.8 optical and electrical bandwidth, graded index optical fiber 1.9 light absorption and scattering 1.10 attenuation in optical fibers.

Text books

1. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson, (2009)
2. Fiber optics and Optoelectronics, R.P. Khare, Oxford University Press, (2004),

Unit II

Laser principles, Photodetectors and photovoltaics (20 hrs)

2.1Laser oscillation conditions, diode laser principles, heterostructure laser diode 2.2 Double heterostructure, stripe geometry, buried heterostructure, gain and index guiding, laser diode characteristics, laser diode equation 2.3 Single frequency solid state lasers,distributed feedback, quantum well lasers, vertical cavity surface emitting laser, optical laser amplifiers. 2.4 Principle of p-n junction photodiode 2.5 Ramo‘s theorem and external photocurrent 2.6 Absorption coefficient and photodiode materials, quantum efficiency and responsivity 2.7 PIN-photodiode, avalanche photodiode, phototransistor, photoconductive detectors and photoconductive gain 2.8 Noise in photo-detectors, noise in avalanche photodiode, solar energy spectrum 2.9 Photovoltaic device principles I-V characteristics, series resistance and equivalent circuit, temperature effects 2.10 Solar cell materials, device and efficiencies

Text books

1. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson, (2009)
2. Laser fundamentals, William T. Silfvast, CUP 2nd Edn. (2009)

Unit III

Optoelectronic modulators and Non-linear optics (16 hrs)

3.1Optical polarization, birefringence 3.2 retardation plates, electro-optic modulators 3.3Pockels effect, longitudinal and transverse electro-optic modulators 3.4 Kerr effect, Magneto-optic effect 3.5 Acousto-optic effect, Raman Nath and Bragg-types. 3.6 Polarization response of materials to light 3.7 Harmonic generation, second harmonic generation 3.8 phase matching, third harmonic generation 3.9 Optical mixing, sum and difference frequencies 3.10 Parametric generation of light, self focusing of intense light beams.

Text books

1.Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson, (2009)

2.Optoelectronics: an Introduction, J. Wilson and J.F.B. Hawkes, PHI, (2000)

3. Lasers and non-linear optics, B. B. Laud, New Age Pub (2011).

Reference Books:

1. Semiconductor optoelectronic devices: Pallab Bhattacharya, Pearson(2008)
2. Optoelectronics: An introduction to materials and devices, Jasprit Singh, McGraw Hill International Edn., (1996).
3. Optical waves in crystals: Propagation and Control of Laser Radiation, A. Yariv and P. Yeh, John Wiley and Sons Pub. (2003)

PH850402: SEMICONDUCTOR DEVICES

Credit-3 (90 Hours)

Objective of the course: Objectives of this subject ensures the students to expand their knowledge in semiconductor physics and provide a foundation for further advanced studies. After completing the course the student will (1) understand the fundamental concepts of charge carriers transport phenomenon in semiconductors (2) Understand the concepts of p-n junction (3) Understand the mode of operations of bipolar transistors (4) Understand the features of Metal-semiconductor and semiconductor hetero-junctions (5) This course also provides the perceptives ofIntegrated Circuit Fabrication and Characteristics

Unit I

Carrier transport phenomena (18 hrs)

1.1 Carrier transport phenomena - carrier drift 1.2Drift current density - mobility effects- conductivity1.3 Velocity saturation - carrier diffusion- diffusion current density- total current density 1.4 Nonequilibrium excess carriers in semiconductors 1.5Semiconductor in equilibrium 1.6 Excess carrier generation and recombination- characteristics of excess carriers 1.6 Continuity equation 1.7Ambipolar transport 1.8Dielectric relaxation time constant- quasi Fermi energy levels 1.9 Excess carrier life time-surface effects.

Text book

1. Semiconductor Physics and Devices, Donald A. Neamen, McGraw Hill

Unit II

PN junction(18 hrs)

2.1 Basic structure of a p-n junction 2.2Built in potential- electric field 2.3 Space charge widths 2.4 Forward and reverse biasing 2.5 Junction capacitance- one sided junctions 2.6 p-n junction current- ideal current voltage relationship 2.7 Boundary conditions, minority carrier distribution 2.8Ideal p-n junction current, temperature effects, short diode 2.9Generation-recombination currents-reverse bias generation current 2.10 forward bias recombination current- total forward bias current-junction breakdown.

Text book

1. Semiconductor Physics and Devices, Donald A. Neamen, McGraw Hill

Unit III

Metal-semiconductor and semiconductor hetero-junctions(18 hrs)

3.1 Metal-semiconductor - Schottky barrier diode - qualitative characteristics – ideal junction properties 3.2 Current voltage relationship, Comparison with junction diode 3.3 Metal semiconductor ohmic contact 3.4 Ideal non rectifying barriers – tunneling barrier – specific contact resistances 3.5 Semiconductorhetero-junctions – hetero-junction materials – energy band diagram –Twodimensional electron gas 3.6 Equilibrium electrostatics

Text book

1. Semiconductor Physics and Devices, Donald A. Neamen, McGraw Hill

Unit IV

Bipolar transistor(18 hrs)

4.1 Bipolar transistor action-basic principle of operation 4.2 Simplified transistor current relations 4.3 Modes of operation- amplification with bipolar transistors 4.4 Minority carrier distribution4.5 Forward active mode- low frequency common-base current gain 4.6 Contributing factors, non-ideal effects-high injection 4.7 current crowding- breakdown voltage 4.8 Transistor equivalent circuit models- Elbers-Moll model-frequency limitations- time delay factors 4.9 Transistor cutoff frequency-large signal switching-switching characteristics.

Text books

1. Solid state electronic devices, Streetman and Banerjee, PHI (2010).
2. Physics of Semiconductor Devices, Michael Shur, PHI (2002).
3. Introduction to Semiconductor materials and Devices, M.S. Tyagi, John Wiley and Sons (2000)

Unit V

Integrated Circuit Fabrication and Characteristics (18 hrs)

5.1 Integrated circuit technology – basic monolithic IC – epitaxial growth –marking and etching 5.2 Diffusion of impurities – transistor for monolithic circuit 5.3.Monolithic diodes – integrated resisters, capacitors and inductors5.4 monolithic circuit layout - additional isolation methods -MSI, LSI, VLSI– the metal semiconductor contact.

Text book

1. Integrated Electronics-Analogue and Digital Circuits and Systems, J Millmann and C CHalkias, TMGH

Reference Books:

1. 0000 to 8085 Introduction to Microprocessors for Engineers and Scientists.- P.K. Gosh & P.R. Sridhar, PHI
2. Advanced microprocessors and peripherals, A.K. Ray & K.M. Burchandi –TMH.
3. Microprocessor and microcontroller, R. Theagarajan- SCITECH Publications India Pvt. Ltd.
4. Microprocessor and Peripherals, S.P. Chowdhury& S. Chowdhury- SCITECH Publications
5. Operating system Principles, Abraham Silberschatz& Peter Baer Galvin & Greg Gagne, John Wiley
6. Solid state electronic devices, Streetman and Banerjee, PHI (2010).
7. Physics of Semiconductor Devices, Michael Shur, PHI (2002).
8. Introduction to Semiconductor materials and Devices, M.S. Tyagi, John Wiley and Sons (2000)

PH850403: CERAMICS AND BIOMATERIALS

Credit - 3 (90 Hours)

UNIT I

Ceramics (18 hrs)

1.1 Introduction to ceramic materials, 1.2 Structure of oxide and nonoxide ceramics, 1.3 Review of defects and diffusion in ionic solids, 1.4 Ionic conductivity. 1.5 Linear dielectrics, 1.6 Frequency dependence of polarization and associated mechanisms, Impedance spectroscopy, 1.7 Breakdown mechanisms, 1.8 Material design for dielectric constants, 1.9 Dielectric materials for microwave, 1.10 thin film capacitor

Text Books

1. Ceramic Materials - Science and Engineering , C. Barry Carter, M. Grant Norton, SpringerScience & Business Media
2. Principles of Electronic Ceramics, L.L. Hench and J. K. West, Wiley

Unit II

Ferroelectric Ceramics (18 hrs)

2.1 Non-linear dielectrics, 2.2 Structural origin of non-linear behaviour, 2.3 Ferroelectrics and Piezoelectrics, 2. 4 Thermodynamic formulation of ferroelectrics, 2.5 Domains, Applications of ferroelectric bulk and thin films, 2.6 Microstructure - property relationships, Applications of piezoelectric materials in transducers, 2.7 electrochemical filters and positioning devices. 2.8 Electro-optic ceramics: Optical phenomena - birefringence, 2.9 linear and quadratic electro-optic effects (Pockels and Kerr)

Text Book

1. Ceramic Materials - Science and Engineering , C. Barry Carter, M. Grant Norton, Springer Science & Business Media

Unit III

Magnetic ceramics (18 hrs)

3.1 Magnetic ceramics and their applications in power transformers, filters, microwave ferrites, recording media, etc. 3.2 New high permeability materials, 3.3 Novel recording media, 3.4 Giant and collosal magneto-resistance, 3.5 Magnetoelectronics. 3.6 High temperature super- conductors: Review of superconductivity and their applications to high field magnets, 3.7 Josephson junction.

Text Book

1. Magnetic Ceramics, Raul Valenzuela, Cambridge University Press

Unit IV

Biomaterial (18 hrs)

4.1 Atomic description of biomolecules: DNA, RNA, and proteins; 4.2 forces and energetic in living systems: cells; 4.3 Statistical physics in biology: energy and entropy in complex biomolecules, 4.4 molecular machines; Molecular modeling of biological problems: Brownian motion and diffusion, 4.5 protein folding, enzyme reaction; 4.6 Biomechanics: statics and human anatomy, 4.7 mechanics of motion.

Text Books

1. Nelson P., Biological Physics: Energy, Information, Life, Freeman.
2. Dill Ken and Bromberg Sarina, Molecular Driving Forces: Statistical thermodynamics in Biology, Chemistry, Physics and Nanoscience, Garland Science.

Unit V

Analysis Techniques (18 hrs)

5.1 Quantitative measurement techniques to investigate biological problems: 5.2. Nuclear magnetic resonance spectroscopy: working, application 5.3 Raman spectroscopy, 5.4 ultrafast spectroscopy, 5.5 magnetic resonance imaging, 5.6 optical microscopy, 5.7 Transmission electron microscopy

Text Books

1. Lodish H. et al., Molecular Cell Biology, Freeman.
2. Alberts B. et. al., Molecular Biology of the Cell,Garland Science.

References Books:

1. Nonstoichiometry, diffusion and electrical conductivity in binary metal oxides, Per Kofstad, Wiley
2. Nonstoichiometric Oxides, O. Toft Sorensen, Academic Press

3. Electroceramics: Materials, Properties, Applications, A. J. Moulson, J. M. Herbert, Wiley
4. Transition Metal Oxides, C.N.R. Rao and B. Raveau, Wiley-VCH
5. Basic Solid State Chemistry, A.R. West, Wiley
6. Structure and Properties of Inorganic Solids, F.S. Galasso, Pergamon Press
7. A textbook of nanoscience and nanotechnology, T. Pradeep, Tata McGraw-Hill Education
8. Fundamentals of Materials Science and Engineering: An Interactive e.Text, 5th Edition by William D. Callister and William D. Callister Jr. Wiley

PH850404: ADVANCED MATERIAL SCIENCE PRACTICALS

Credit-5 (180 hours)

(Minimum of 12 Experiments should be done)

1. Determine the dielectric constant of a non-polar liquid using a cylindrical capacitor.
2. Measure the electrical and thermal conductivity of copper and determine the Lorentz number.
3. Crystal growth – Slow evaporation technique – determination of saturation coefficient and linear density.
4. Synthesis of nano particle by Sol-gel method
5. Preparation of glassy materials using Solgel technique
6. Thin film fabrication using dip coating technique and its thickness measurements
7. Morphological analysis of nano particles using simulation technique and Sherrer equation
8. XRD – Crystal structure determination Cubic/ Hexagonal
9. XRD – Determination of Crystal size and lattice strain
10. Electrical conductivity of electrolytes using conductivity meter and its PH measurements
11. Study the photo conductivity characteristics of a semiconducting material with the variation in light intensity.
12. Determine the dipole moment of an organic molecule using a cylindrical capacitor.
13. Using hall effect set up, determine (a) Hall coefficient (b) Mobility of charge

carriers (c) Carrier concentration.

14. Calibrate a thermocouple as a temperature sensor.
15. Study the beam profile and determine the spot size of diode laser.
16. Determine the absolute Seebeck co-efficient of copper and constantan as a function of temperature.
17. Determine the Lande g-factor of electron using an ESR spectrometer.
18. Determine the magnetic susceptibility of a paramagnetic solution by Quincke's method and hence prove that water is diamagnetic.
19. Verify Malu's law of polarization using a He-Ne laser.
20. Measure the coefficient of linear expansion of a solid by Fizeau's interferometer configuration.
21. Determination of track width and pit width for a CD/DVD using laser beam.
22. Measure the absolute Seebeck coefficient of n-type and p-type Bismuth telluride.
23. Study the photo conductivity characteristics of a semiconducting material with the variation in light intensity.
24. Study the dependence of Hall coefficient on temperature and nature of majority charge carriers using Hall effect set-up.
25. Determine the average wavelength of sodium D lines and the thickness of a glass slide using a Michelson Interferometer.
26. Determine the band gap energy of germanium using a reverse biased p-n junction diode.
27. Determine the drift mobility of carriers in a semiconductor specimen using Haynes-Shockley experiment.
28. Determine the minority carrier life time of a semiconductor specimen using photoconductive decay method.
29. Determine the dielectric constant of a sheet by using it as a parallel plate capacitor in an oscillator.
30. Determine the dielectric constant of ADP/ KDP crystal using electro-optic effect.
31. Study the resistivity of a single crystal by four probe method at constant deviation of temperature and find the energy gap of the material.
32. Compare the optical absorption spectrum of a direct and an indirect bandgap semiconductor specimen and estimate the bandgap in each case.
33. Determination of lattice constant of a cubic crystal with accuracy and indexing

the Bragg reflections in a powder X-ray photograph of a crystal.

34. Study the I-V characteristics, I-P characteristics, modulation bandwidth and output spectrum of an LED.
35. Determination of characteristics of a solar cell.
36. To study the photoelectric effect and determination of Plank's constant using LED.
37. Ultrasonic Interferometer – ultrasonic velocity in liquids
38. Study the dielectric property of a thin film using LCR Q-Meter.
39. Study the structural and melting transition in KNO_3 using a differential thermal analyzer

4.3 M.Sc. PHYSICS - MATERIAL SCIENCE

MODEL QUESTION PAPERS

MAHATMA GANDHI UNIVERSITY

PG-CSS PHYSICS MODEL QUESTION PAPER

First Semester

Faculty of Science

Physics- Material Science

PH020101: APPLIED MATHEMATICS FOR PHYSICS- I

(2019 admission onwards)

Time: 3 Hours Maximum Weight: 30

Part A

*Answer any **eight** questions.*

Each question carries 1 weight.

1. Define matric tensor.
2. Distinguish between contravariant and covariant tensor.
3. State Stokes theorem.
4. Show that for Hermitian matrices A & B, which obeys AB – BA = i C, C is also hermitian.
5. Show that $\nabla \times (\nabla \times \vec{A}) = \nabla (\nabla \cdot \vec{A}) - \nabla^2 \vec{A}$
6. Calculate the work done when a force F = 3xy i – y^2 moves a particle in the xy – plane from (0, 0) to (1, 2) along the parabola $y = 2x^2$.
7. Express $\nabla \phi$ in orthogonal curvilinear coordinates.
8. Write a note on inner product space.
9. Prove that Christoffel symbol of first kind is not a tensor.
10. Show that in Euclidian space the Geodesics create straight line.

(8 x 1 = 8)

Part B

*Answer any **six** questions.*

Each question carries 2 weights.

11. Obtain the Recurrence relation for Lauguerre polynomials:

$(n+1)\, L_{n+1}(x) = (2n+1 - x)\, L_n(x) - n\, L_{n-1}(x)$

12. Show that rotation of co-ordinate is orthogonal transformation.

13. Diagonolize matrix

$$A = \begin{pmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 1 \end{pmatrix}$$

14. Show that any inner product of the tensors $A^p{}_r\ B_t^{qs}$ is a tensor of rank 3.

15. Show that eigen values of hermitian matrix are real and its eigen vectors corresponding to two distinct eigen values are orthogonal.

16. Explain Poisson distribution with one example.

17. Prove the orthogonality relation for Bessel function
$\int_0^1 x J_n(\alpha x) J_n(\beta x) dx = 0$

18. Prove the relations (a) $H_n(-x) = (-1)^n H_n(x)$ (b) $H_n'(x) = 2nH_{n-1}(x)$

(6 x 2 = 12)

Part C

*Answer any **two** questions.*

Each question carries 5 weights.

19. Find $\nabla \cdot \vec{A}$ and $\nabla \times \vec{A}$ in orthogonal curvilinear coordinates.

20. Obtain generating function for Laguerre function and find the value of:m$J_{1/2}$ (x) and $J_{+3/2}$ (x)

21. Find the inverse of

$$A = \begin{pmatrix} 2 & 2 & 1 \\ 1 & 3 & 2 \\ 1 & 1 & 3 \end{pmatrix}$$

22. Write the mathematical form of generalized covariant derivative of a tensor of arbitrary rank? Derive the expression for j^{th} covariant derivative of a tensor?

(2 x 5 = 10)

MAHATMA GANDHI UNIVERSITY

PG-CSS PHYSICS MODEL QUESTION PAPER

First Semester

Faculty of Science

Physics- Material Science

PH020102: BASIC QUANTUM MECHANICS

Time : 3 Hours. Maximum Weight: 30

Part A

*Answer any **eight** questions.*

Each question carries 1 weight.

1. Write a note on Dirac's bra and ket notation.
2. Mention any two properties of inner product.
3. What is zero point energy of harmonic oscillator? Explain it with the help ofuncertainty principle.
4. What are the basic quantum numbers that designatethe states of hydrogen atom? Give the allowed values of these quantum numbers.
5. What is time evolution operator? Give its properties.
6. Observables are Hermitian operators. Why?
7. Why J_+ and J_- are called raising and lowering operator?
8. What are Pauli spin matrices? Explain their properties.
9. Explain the condition for validity of WKB approximation.
10. Distinguish between Schrodinger picture and Heisenberg picture.

(8 x 1 = 8)

Part B

*Answer any **six** questions.*

Each question carries 2 weights.

11. Discuss the Zeeman effect.
12. Derive the general uncertainty relationship.
13. Explain the variation principle for determining the ground state energy of a system.

14. State and explain Ehrenfest's theorem.
15. If L= r x p, prove that[Lx, Ly] = iħLz.
16. Derive matrices for the operators J^2, J_z, J_x and J_y for j= 3/2.
17. Explain Schrodinger and Heisenburg pictures in quantum mechanics
18. Explain Stern-Gerlach experiment.

(6 x 2 = 12)

Part C

*Answer any **two** questions.*

Each question carries 5 weights.

19. Comment on position and momentum space wave functions. Also prove that Gaussian wave packet is a minimum uncertainity wave packet.
20. Solve the problem of linear harmonic oscillator using creation and annihilation operators.
21. Obtain the matrix elements of J^2 and J_z in a representation in which J^2 and J_z are diagonal.
22. Derive an expression for transmission coefficients through a potential barrier.

(2 x 5 = 10)

MAHATMA GANDHI UNIVERSITY

PG-CSS PHYSICS MODEL QUESTION PAPER

First Semester

Faculty of Science

Physics- Material Science

PH020103: CONDENSED MATTER PHYSICS

(2019 admission onwards)

Time: 3 Hours. Maximum Weight: 30

Part A

*Answer any **eight** questions.*

Each question carries 1 weight.

1. What are ferroelectric crystals? Name any two components that exhibit ferroelectricity.
2. What are ferroelectric domains?
3. Differentiate Type1 and Type2 superconductors.
4. Differentiate diamagnetic and paramagnetic materials.
5. What is Hall Effect?
6. Explain the isotope effect in Super Conductivity.
7. Distinguish between acoustic and optical phonons.
8. Explain the effective mass of electron.
9. Explain Bloch theorem.
10. Explain harmonic approximation in lattice vibrations.

(8 x 1 = 8)

Part B

*Answer any **six** questions.*

Each question carries 2 weights

11. (a) For argon gas, N= $10^{19}cm^{-3}$, Z= 18 and r= 10^{-8}cm. Calculate the electronic polarization for an applied field of 10 KV/cm. (b) Silicon has the dielectric constant 12, and edge length of the conventional cubic cell of Silicon lattice is $5.43A^0$. Calculate the electronic polarisability of Silicon atoms.

12. Show that the intermediate state consists of regions of normal and superconducting metal.

13. Show that how the London equations lead to the Meissner effect and the flux penetration through thin films of superconductors.

14. Discuss the normal and umklap process.

15. Explain the inelastic scattering of neutrons by phonons.

16. A two –dimensional hexagonal lattice spacing a = 3 A^0 , and one electron per unit cell. If the electrons are considered free within the two – dimentional plane, what is the Fermi energy $\mathbf{E_F}$ (Provide a numerical value in eV).

17. Derive an expression for the density of available electron states

18. Explain Wiedemann Franz law.

(6 x 2 = 12)

Part C

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

Each question carries 5 weights.

19. What is single particle tunneling. Derive an expression for AC and DC Josephson effects.

20. Distinguish between diamagnetism and paramagnetism. Derive Langevin's diamagnetic equation.

21. Discuss Debye model of lattice heat capacity. Derive an expression for it.

22. What is Fermi surface? Discuss the construction of Fermi surfaces.

(2 x 5 =10)

MAHATMA GANDHI UNIVERSITY

PG-CSS PHYSICS MODEL QUESTION PAPER

First Semester

Faculty of Science

Physics- Material Science

PH020104: CLASSICAL MECHANICS AND RELATIVITY

Time: 3 Hours Maximum Weight: 30

Part A

Answer any ***eight*** *questions.*

Each question carries 1 weight.

1. State the Hamiltonian conservation theorem.
2. State and explain the least action principle.
3. Derive the relationship between Poisson bracket and Lagrange bracket.
4. How does the short wavelength limit of Schroedinger equation leads to Hamilton-Jacobi equation?
5. Discuss the nature of Coriolis' force.
6. What are the advantages of Hamiltonian formalism over Lagrangian formalism?
7. State the Kepler's laws of planetary motion.
8. Outline the principle of equivalence.
9. What is meant by a linear system and a non linear system?
10. What is Lyapunov exponent? What is its significance?

(8×1=8)

Part B

Answer any ***six*** *questions.*

Each question carries 2 weights.

11. Using Hamilton's equations, show that the angular momentum is conserved in a central force problem.

12. Using Poisson brackets, check whether the transformation defined by

$q = \sqrt{2P} sinQ$

$p = \sqrt{2P} cosQ$ is canonical.

13. Prove that the rotational kinetic energy is conserved in the torque free motion of a

rigid body.

14. For a diatomic molecule consisting of masses m1and m2 connected by a spring of force constant k vibrating along the line joining the masses, determine the normal frequencies and normal co-ordinates.

15. Solve the differential equation of a linear harmonic oscillator $\frac{d^2x}{dt^2} + \omega_o^2 x = 0$ by quadrature method.

16. Solve the problem of Harmonic oscillator by Hamilton-Jacobi method.

17.Obtain the Lagrangian for a charged particle moving in an electromagnetic field

18. Obtain the lagrangian equation for a spherical pendulum.

(6×2=12)

Part C

*Answer any **two** questions.*

Each question carries 5 weights.

19. What is Hamilton's principle? Obtain Lagrange's equations from Hamilton's principle using the calculus of variation.

20. Obtain the Lagrange's equations for small oscillations of a system of two coupled oscillators in the neighborhood of stable equilibrium.Obtain the normal modes and the normal co-ordinates. .

21. Discuss the precessional motion with and without nutation of a spinning symmetrical top under gravity.

22. Derive Einstein's field equations. (ii).Write a note on gravitational red shift.

(5×2=10)

MAHATMA GANDHI UNIVERSITY

PG-CSS PHYSICS MODEL QUESTION PAPER

Second Semester

Faculty of Science

Physics- Material Science

PH020201: APPLIED MATHEMATICS FOR PHYSICS – II

(2019 admission onwards)

Time: 3 Hours | Maximum Weight: 30

Part A

*Answer any **eight** questions.*

Each question carries 1 weight.

1. If $f(z) = \sin z$, show that $f^{*}(z) = f(z^{*})$ for complex z.
2. Check whether $f(z) = i^{Z}$ is analytic.
3. Explain cyclic group with example.
4. Prove that inverse of any element of group is unique.
5. Write down two partial differential equations and their relevance in physics.
6. Write short note on the different boundary conditions employed to solve differential equations.
7. Obtain the Laplace transform of $f(x) = x^{n}$
8. Define the Fourier transform of a function $f(x)$. What is the Fourier transform of its first derivative?
9. What is meant by Earth's Nutation?
10. Explain SU (3) flavor symmetry and SU(3) colour symmetry.

(8 x 1 = 8)

Part B

*Answer any **six** questions.*

Each question carries 2 weights.

11. Evaluate $\int_C \frac{2z-1}{z(z+1)(z+3)}dz$, where C is $|Z|$ = 2 using Residue Theorem.

12. Obtain the Laurent expansion of the function f (z) about $z = z_0$.

13. Show that the Fourier transform of a Gaussian function is another Gaussian.

14. Prove that the set of all matrices $\begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix}$ for $0 \le \theta \le 2\pi$ form a Lie group.

15. State and prove convolution theorem of Laplace transforms.

16. Separate the partial differential equation $\nabla^2\psi(\rho, \phi, z) + k^2\psi(\rho, \phi, z) = 0$ in to three ordinary differential equations.

17. Obtain the momentum representation of a wave function $\psi(x) = \sqrt{a}\ \exp(-x^2/2a^2)$

18. Obtain a general solution of Laplace equation in circular cylindrical co-ordinates.

(6 x 2 = 12)

Part C

*Answer any **two** questions.*

Each question carries 5 weights.

19. State and prove Cauchy's integral theorem. Deduce Cauchy's integral formula from it.

20. State Schur's lemmas and prove the great Orthogonality theorem.

21. Solve the differential equation for the electric charge in a series LCR circuit using Laplace transform.

22. Solve Poisson's Equation using Green's function.

(2 x 5 = 10)

MAHATMA GANDHI UNIVERSITY

PG-CSS PHYSICS MODEL QUESTION PAPER

Second Semester

Faculty of Science

Physics- Material Science

PH020202: ELECTRODYNAMICS AND ELECTROMAGNETIC WAVES

(2019 admission onwards)

Time: 3 Hours Maximum Weight: 30

Part A

*Answer any **eight** questions.*

Each question carries 1 weight.

1. Write a short note on Maxwell's stress tensor.
2. State and explain second uniqueness theorem.
3. Why TEM wave cannot propagate through a wave guide?
4. Show that the four dimensional divergence of current density 4- vector is divergenceless.
5. Discuss the significance of Jefimenko's Equations.
6. What is meant by gauge transformation?
7. Write a short note on radiation reaction.
8. What is meant by dispersion in dielectrics?
9. Define proper velocity and proper time.
10. Obtain the expression for momentum of monochromatic plain waves.

(8 x 1 = 8)

Part B

*Answer any **six** questions.*

Each question carries 2 weights.

11. From Maxwell's equations obtain wave equation for an electromagnetic field. Identify the velocity of propagation.
12. Prove that dipole moment is independent of choice of origin if total charge of the system is zero.
13. For a TM wave between parallel plate, find the expression for cut off frequency.

14. A pion at rest decays into a muon and a neutrino. Find the energy of outgoing muon interms of 2 masses, m_π and m_μ ,(assume m_ν=0).
15. Obtain an expression for the fields of a moving point charge.
16. Show that $E^2 - c^2B^2$is relativistically invariant.
17. Show that when a uniform plane wave propagates in a good conductor, the magnetic field lags electric field by 45°.
18. Prove that R + T = 1 for a wave incident normally on a boundary separating two media.

(6 x 2 = 12)

Part C

*Answer any **two** questions.*

Each question carries 5 weights.

19. What is Poynting vector? Show that for a lossless medium, the total power flowing into a closed surface equal to the rate of increase of electric and magnetic energies in the closed volume.
20. Reformulate Maxwell's equations using relativistic tensor notation of fields.
21. Explain electric dipole radiation.
22. Explain the propagation TE waves in rectangular waveguide.

(2 x 5 = 10)

MAHATMA GANDHI UNIVERSITY

PG-CSS PHYSICS MODEL QUESTION PAPER

Second Semester

Faculty of Science

Physics- Material Science

PH020203:ADVANCED ELECTRONICS AND COMMUNICATION

(2019 admission onwards)

Time: 3 Hours Maximum Weight: 30

Part A

*Answer any **eight** questions.*

Each question carries 1 weight.

1. Do we get a voltage follower with inverting amplifier? Explain.
2. Explain slew rate.
3. Explain the working of zero crossing detectors.
4. Distinguish between FET and JFET.
5. Explain the performance of a summing amplifier.
6. Discuss balanced modulator.
7. Explain the fundamental principle of VCO with a diagram.
8. Give the effect of variation in power supply voltage on offset voltage.
9. What determines peaking frequency in the peaking amplifier?
10. Explain the frequency response of an op-amp.

(8 x 1 = 8)

Part B

*Answer any **six** questions.*

Each question carries 2 weights.

11. Draw and explain the operation of a triangular wave generator.
12. Calculate the exact voltage gain of a negative voltage series feedback OP-AMP circuit from the following data. Open loop voltage gain = 1000, feedback resistor, R_F= 22K, and series resistor R_1= 1K.

13. The CMRR of an OP-AMP is ratedat 80db.If its common mode gain is measured as 0.5, calculate the o/p corresponding to a differential input of 10μV.
14. What are the different types of pulse modulation? Explain with waveforms, how it is derived from PWM.
15. Explain how sinusoidal waves are generated in an OP-AMP Wien bridge oscillator circuit.
16. Briefly explain the working of an integrator.
17. Briefly explain voltage series feedback in op-amps.
18. What are the applications of IC565PLL

(6 x 2 = 12)

Part C

*Answer any **two** questions.*

Each question carries 5 weights.

19. What is frequency modulation? Explain FM generation and detection.
20. Draw the two differential amplifier configurations based on the no of Op-Amps used. Calculate the voltage gain, input resistance, output resistance of a differential amplifier using any of the two configurations.
21. Discuss closed loop frequency response of an Op-Amp and briefly explain circuit stability.
22. Explain the action of a low – pass first order Butterworth filter.How it is converted into a second order filter? Draw the frequency response curves.

(2 x 5 = 10)

MAHATMA GANDHI UNIVERSITY

PG-CSS PHYSICS MODEL QUESTION PAPER

Second Semester

Faculty of Science

Physics- Material Science

PH020204: ADVANCED NUCLEAR PHYSICS

(2019 admission onwards)

Time: 3 Hours Maximum Weight: 30

Part A

*Answer any **eight** questions.*

Each question carries 1 weight.

1. What are quarks? Name the different flavours of quarks.
2. Distinguish between leptons and hadrons.
3. The binding energy per nucleon is low at low mass numbers and high mass numbers. Explain.
4. Explain the ground state of deuteron. Plot the wave function for the deuteron ground state taken as an S-state.
5. Express the Gell-mann-Nishijima formula.
6. What are isomeric transitions?
7. Explain Q value of nuclear reaction.
8. Give the selection rule for forbidden decays.
9. What are power reactors?
10. What are magic numbers? What are singly and doubly magic nuclei. List magic numbers below 100.

(8 x 1 = 8)

Part B

*Answer any **six** questions.*

Each question carries 2 weights.

11. The ground state of ${}_{55}Cs^{137}$ 7/2+ decays with a half life 33 years,92% by β emission to an excited state of ${}_{56}Ba^{137}$(which in turn decays by γ emission with half life 2.6 minutes to theground state Ba^{137})and 8%by β emission directly the ground

state. Following quantities were measured ˙(K.E)$_{\beta}$max(92%)=0.51MeV (K.E)β max(8%)=1.17MeVWhat is the degree of forbiddenness of each transition?

12. How many α and β particles are emitted when $_{92}U^{238}$decay to Lead ($_{82}$ Pb^{206}).

13. ^{7}Li (Z=3) and ^{7} Be(Z=4) have the atomic masses 7.016005 and7.016929u. Which of then shows β activity and of what type? Calculate Q for it.

14. Find the energy release of two $_{1}H^{2}$ nuclei can fuse together to form $_{2}He^{4}$ nucleus. The binding energy per nucleon of H^2 and He^4 is 1.1Mev and 7.0 respectively.

15. Show that nuclear density of $_{1}H^{1}$ is about 1014 times greater than atomic density assume the atom have the radius of the first Bohr model.

16. A reactor is developing energy at the rate of 1500KW.How many atoms of U^{235} undergo fission per second? How many Kg of U^{235} would be used in 1000 hours of operation assuming that on an average energy of 200MeV is released per fission.

17. Describe the angular momentum and parity of the nuclei.

18. Explain the magnetic dipole moment and electric quadrupole moment of the nuclei..

(6 x 2 = 12)

Part C

*Answer any **two** questions.*

Each question carries 5 weights.

19. Describe Fermi theory of β decay. Calculate the energy release in β decay process.

20. Explain electric quadrapole moment for an ellipsoidal charge distribution.

21. Describe quark model of elementary particles.

22. What is the evidence for shell structure of the nucleus? Sketching the main assumptions, explain the shell model of the nucleus.

(2 x 5 = 10)

MAHATMA GANDHI UNIVERSITY

PG-CSS PHYSICS MODEL QUESTION PAPER

Third Semester

Faculty of Science

Physics- Material Science

PH020301: STATISTICAL PHYSICS AND ASTROPHYSICS

(2019 admission onwards)

Time : 3 Hours. Maximum Weight : 30

Part A

*Answer any **eight** questions.*

Each question carries 1weight.

1. In terms of density matrix state the conditions for statistical equilibrium.
2. What are statistical ensembles? Give their classification with suitable examples.
3. What is meant by Ising model?
4. Discuss Pauli's theory of paramagnetism.
5. State Wiener Khintchine theorm.
6. Define partition function in canonical ensemble.
7. Write a brief note on Quasars.
8. Explain Chandrasekhar Limit.
9. What are Magnetars?
10. What is meant by colour index of a star?

(8x1 = 8)

Part B

*Answer any **six** questions.*

Each question carries 2 weights.

11. What is Fermi gas? Explain the thermodynamic behavior of an ideal Fermi system.
12. The molar mass of lithium is 0.00694 and its density is $0.53x10^3 kg/m^3$.Caluculate the Fermi energy and Fermi temperature of the electrons.
13. Derive grand partition function. How can you obtain the various thermodynamic quantities from it?

14. Discuss on density and energy fluctuations in the grand canonical ensemble.
15. Discuss the phenomenon of Bose Einstein condensation in momentum space and hence explain the properties of liquid He-II.
16. Explain the two main processes behind the energy generation in stars.
17. Explain Virial theorem.
18. Define luminosity of a star. Derive the relationship between the luminosity and absolute magnitude. Derive relation between entropy and canonical partition function.

(6x2 = 12)

Part C

*Answer any **two** questions.*

Each question carries 5 weights

19. What is Bragg William approximation. How energy equation of Ising model is expressed in this approximation
20. Explain the thermodynamics of an ideal gas in canonical ensemble
21. Explain Saha's equation of thermal ionization and its applications.
22. ExplainHertz Sprung Russell diagram.

(2 x 5 =10)

MAHATMA GANDHI UNIVERSITY
PG-CSS PHYSICS MODEL QUESTION PAPER
Third Semester
Faculty of Science
Physics- Material Science
PH020302: NUMERICAL METHODS IN PHYSICS
(2019 admission onwards)

Time: 3 Hours Maximum Weight: 30

Part A

Answer any ***eight*** *questions.*

Each question carries 1 weight.

1. Discuss the uses of Lagrange's interpolation formula.
2. What do you mean by truncation error?
3. Why Trapezoidal rule is called so?
4. Explain Gauss – Seidel method for solution of Laplace equation.
5. What do you mean by marching methods for the solution of ordinary differential equations?
6. What is the basic idea behind predictor-corrector methods?
7. How will you find the inverse of a matrix by Gauss – Jordan method?
8. Obtain finite difference approximation to derivatives.
9. Show that divided differences are symmetrical in their arguments.
10. Write a note on Milne's method. (8 x 1 = 8)

Part B

Answer any ***six*** *questions.*

Each question carries 2 weights.

11. Using Romberg's method, compute $I=\int_0^1 \frac{1}{1+x}dx$ correct to 3 decimal places.
12. Given $\frac{dy}{dx} = y - x$, with $y(0)=2$. Find $y(0.1)$ and $y(0.2)$ correct to 4 decimal places.
13. The following data gives the melting point of an alloy of lead and zinc

% of lead in the alloy	40	50	60	70	80
Temperature in ^oC	201	206	225	251	276

Find the melting point of the alloy containing 48% of lead using Newton's forward Interpolation formula

14. Find the Lagrange's interpolation polynomial of degree 2 approximating the function y=ln(x) defined by the following table of values. Hence find the value of ln(2.7).

15. Solve the differential equation $(1+x)\frac{dy}{dx}+y=0$ with $y(0)=2$ for $x=1.5$ to $x=2.5$ using fourth order Runge – Kutta method with $h=0.25$.

16. Solve the following system of equations by Gauss elimination method

$$10x+y+z=12$$
$$x+10y+z=12$$
$$x+y+10z=12$$

17. Solve one dimensional heat equation

$$U_t=U_{xx}$$

with the conditions $U(x,0)=\ x^2-4x, 0\le x\le 4, U(0,t)=0\ , U(4,t)=0$ using Schmidt formula.

18. Find the equation of least square that fit a line y= a_0+a_1x for the following data.

X	5	10	15	20	25
Y	16	19	23	26	30

(6 x 2 = 12)

Part C

*Answer any **two** questions.*

Each question carries 5 weights.

19. Explain the method of least square curve fitting. How can you fit a straight line and an exponential function to given data points.

20. Describe Milne's method. Given

$$y'=1+y^2$$

with *y(0)=0*. Find *y(0.8) and y(1.0).*

21. Explain numerical double integration. Use trapezoidal rule to evaluate the double integral

$\int_{-2}^{2}\int_{0}^{4}(x^2-xy+y^2)dx\,dy.$

22. Solve by Crank – Nicolson method

$$\boldsymbol{u_t}=\boldsymbol{2u_{xx}}$$

subject to conditions $u\ (x,0)=\sin\pi x\ ,0\le x\le 1$ and $u\ (0,t)=0$, $u(1,t)=0$, t > 0. With h= 1/4 and k=1/16, compute (1 /2, 1/ 8).

(2 x 5 = 10)

MAHATMA GANDHI UNIVERSITY
PG-CSS PHYSICS MODEL QUESTION PAPER
Third Semester
Faculty of Sciences
Physics – Material Science
PH020303: ADVANCED QUANTUM MECHANICS
(2019 admission onwards)

Time: 3 Hours Maximum Weight: 30

Part A

*Answer any **eight** questions.*

Each question carries 1 weight.

1. What is Noether's theorem and its consequences?
2. Write down the properties of Dirac matrices ϒ.
3. Discus bilinear co variants in Dirac's theory.
4. Discuss the probability conservation and its importance in relativistic quantum mechanics.
5. What is the resonance scattering? Give an example.
6. Define scattering length. How it is related to zero energy cross section?
7. Discuss Ramsaur-Townsend effect.
8. What are the short comings of Klein-Gordon equation?
9. Describe Fermi's golden rule.
10. Distinguish between interaction picture and Schrodinger picture.

(8 x 1 = 8)

Part B

*Answer any **six** questions.*
Each question carries 2 weights.

11. What is non relativistic limit of Dirac equation? Explain the various terms.
12. In relativistic quantum mechanics, derive the approximate Hamiltonian for an electrostatic problem.
13. Discuss the bound state problem of deuteron.
14. Obtain the relation between scattering amplitude and differential cross section.
15. Discuss sudden and adiabatic approximation with an example.
16. Establish the formula for expanding plane wave in terms of partial waves.
17. Explain Electric Dipole Approximation.
18. Explain Optical Theorem.

(6 x 2 = 12)

Part C

*Answer any **two** questions.*

Each question carries 5 weights.

19. What is transition probability? Obtain an expression for total transition probability in case of constant perturbation.
20. Derive the expression for scattering amplitude using Born approximation.
21. Derive the nonrelativistic limit of Dirac equation.
22. Derive the second quantization of the free electromagnetic field.

(2 x 5 = 10)

MAHATMA GANDHI UNIVERSITY

PG-CSS PHYSICS MODEL QUESTION PAPER

Fourth Semester

Faculty of Science

Physics- Material Science

PH020401: ATOMIC AND MOLECULAR SPECTROSCOPY

(2019 admission onwards)

Time: 3 Hours Maximum Weight:30

Part A

*Answer any **eight** questions.*

Each question carries 1 weight.

1. What is the importance of Lande g factor?
2. How hyper fine structure is obtained in atomic spectra?
3. The intensity of J =0 →J=1 is often not the most intense rotational line. Why?
4. What are Fortrat parabolae?
5. Briefly explain the hot bands in IR spectra.
6. Explain inverse Raman scattering.
7. Intense light sources are needed for the observation of nonlinear Raman effects. Why?
8. Explain Frank-Condon Principle.

9. What is the significance of Bloch equations in NMR spectroscopy?
10. How s-electron density is related to chemical isomer shift?

(8×1=8)

Part B

*Answer any **six** questions.*

Each question carries 2 weights.

11. Calculate the Doppler velocity corresponding to the natural line width of the γ-ray emission line from 23.9 keV excited state of ^{119}Sn nucleus having a half life of 1.9×10^{-8}s.
12. Discuss the theory of stark effect in one electron system.
13. The moment of inertia of the CO molecule is 1.46×10^{-46} Kgm^2. Calculate the energy and angular velocity in the lowest rotational energy level of the CO molecule.
14. The Raman line associated with a vibrational mode which is both Raman and Infrared active is found at $4600A^0$ when excited by light of wavelength $4358A^0$. Calculate the wavelength of the corresponding infrared band.
15. Define chemical shift with example. Distinguish between δ and τ chemical shift.
16. The limit of continuum absorption for iodine occurs at 499.5 nm. What is the energy of dissociation of iodine into one normal and one excited atom? Calculate the dissociation energy of iodine molecule into normal atoms, if the lowest excitation energy is 0.94 eV.
17. Describe the theory of ESR and explain the origin of hyperfine structure with one example?
18. Define chemical shift with example. Distinguish between δ and τ chemical shift.

(6×2=12)

Part C

*Answer any **two** questions.*

Each question carries 5 weights.

19. Explain the theory of anomalous Zeeman effect. Discuss under what condition

    Zeeman effect changes to Paschen- back effect
20. Discuss rotational spectra of a non-rigid rotator.
21. What are the informations one can get from a vibrational analysis of an electronic vibration spectra. Explain it with Deslandres table.
22. Describe the spin –spin and spin –lattice relaxation processes with theory.

(5×2=10)

Bunch A: Material Science - I

MAHATMA GANDHI UNIVERSITY

PG-CSS PHYSICS MODEL QUESTION PAPER

Third Semester

Faculty of Science

Physics- Material Science

PH840301: THIN FILM SCIENCE AND CRYSTAL GROWTH TECHNIQUES

(2019 admission onwards)

Time: 3 Hours MaximumWeight:30

Part A

*Answer any e**ight** questions.*

Each question carries 1 weight.

1. What is Nucleation? Write different types of nucleation.
2. Write a note on Epitaxy.
3. Explain the principle of diffusion pump.
4. Explain Zone melting in crystal growth process.
5. What are the merits of Bridgeman technique?
6. Explain the working of Gaede’s rotary oil pump.
7. Write different optical methods for thin film thickness measurements.

8. Explain different techniques for thinfilm growth under chemical vapor deposition.
9. Explain the criteria for vapor transport mechanism.
10. Give the principle of Pulsed Laser deposition.

(8x1= 8)

Part B

*Answer any **six** questions.*

Each question carries 2 weights.

11. What is Pirani gauge? Explain its construction and working.
12. Discuss the spectrometric method of measuring the thickness of a film.
13. Explain Verneuil's flame fusion technique.
14. Write about the growth of ADP crystals.
15. Explain the Langmuir theory for Physical vapor deposition technique.
16. Differentiate between flash evaporation and arc evaporation techniques.
17. Calculate the thickness of Silicon dioxide thin film having film reflectance of 4 maxima and minima; refractive index 2 uses a photometric method? (Given the wave length of light is 1μm)
18. Explain the working of piezoelectric thickness monitor arrangement

(6x 2 = 12)

Part C

*Answer any **two** questions.*

Each question carries 5 weights.

19. Explain the morphological, structural and optical properties of thin films.
20. Explain Czocharalski method for crystal growth technique.
21. Discuss different sputtering methods for deposition of thin films.
22. Discuss the hydrothermal growth of crystals.

(2 x 5 = 10)

MAHATMA GANDHI UNIVERSITY

PG-CSS PHYSICS MODEL QUESTION PAPER

Fourth Semester

Faculty of Science

Physics- Material Science

PH840402: NANOSCIENCE AND NANOTECHNOLOGY

(2019 admission onwards)

Time: 3 Hours Maximum Weight:30

Part A

*Answer any **eight** questions.*

Each question carries 1 weight.

1. List out four challenges faced by Nanotechnology.
2. What is the likely impact of nanotechnology?
3. Describe the optical properties of Semiconducting Nanoparticles.
4. What areMetalnanoclusters?
5. Explain the concept of environmental TEM.
6. What is a Scanning transmission electron microscopy?
7. Briefly explain fullerenes and fullerene-derived crystals.
8. What is the significance of Nano manipulation?
9. Explain the Mechanism of scanning probe lithography.
10. Write a note on magnetic nanostructures.

(8×1=8)

Part B

*Answer any **six** questions.*

Each question carries 2 weights.

11. What are the general issues of concern of synthesis of Nanomaterial?
12. With suitable diagram explain the processes Solvothermal synthesis of nanoparticles.
13. Explain the process of exciton confinement in quantum dots.
14. Describe the mechanism of band gap engineering and optical response.
15. How can the electron diffraction pattern be indexed?

16. Explain the working of Scanning probe lithography and also mention its advantages.
17. Explain the properties of ordered mesoporous structures and random mesoporous structures.
18. Describe the Lithography Concepts of nanotechnology and its application.

(6×2=12)

Part C

*Answer any **two** questions.*

Each question carries 5 weights.

19. Explain the Quantum mechanics of low dimensional systems and confined nanoclusters.
20. Discuss the structure, principle, and working of Scanning Electron Microscopy (SEM).
21. Explain the properties of metal-polymer nanocomposite structures.
22. Describe the Mechanism of molecular transport and its advanced application.

(5×2=10)

MAHATMA GANDHI UNIVERSITY

PG-CSS PHYSICS MODEL QUESTION PAPER

Fourth Semester

Faculty of Science

Physics- Material Science

PH840403: MATERIALS SCIENCE AND ENGINEERING

(2019 admission onwards)

Time: 3 Hours Maximum Weight:30

Part A

*Answer any **eight** questions.*

Each question carries 1 weight.

1. Distinguish between ceramics and polymers.
2. What is a Burgers vector?
3. What is the difference between atomic mass and atomic weight?
4. What is meant by self-diffusion?

5. Write the difference between isotropy and anisotropy
6. What is isomerism?
7. What is the difference between Frenkel defect and schottky defect?
8. What is modulus of elasticity?
9. What are refractories?
10. What is graphite?

(8 x 1 = 8)

Part B

*Answer any **six** questions.*

Each question carries 2 weights.

11. Copper has an atomic radius of 0.128 nm (1.28A°), an FCC crystal structure, and an atomic weight of 63.5 g/mol. Compute its theoretical density.
12. Briefly explain the different structures of polymer molecule.
13. Distinguish between Thermoplastic and Thermosetting Polymers.
14. Calculate the equilibrium number of vacancies per cubic meter for copper at1000^{0}C. The energy for vacancy formation is 0.9 eV/atom; the atomic weight and density (at 1000^{0}C) for copper are 63.5 g/mol and 8.40 g/cm3, respectively.
15. Explain the mechanical behaviour of ceramic materials.
16. Compute the strain-hardening exponent n in Equation 7.19 for an alloy in which a true stress of 415 MPa (60,000 psi) produces a true strain of 0.10;assume a value of 1035 MPa (150,000 psi) for K.
17. Distinguish between ferrous and nonferrous alloys.
18. Explain tear strength and hardness of polymers.

(6 x 2 = 12)

Part C

*Answer any **two** questions.*

Each question carries 5 weights.

19. Explain the different types of bonding in materials.
20. Briefly explain the various defects in solids.
21. Discuss the various diffusion mechanisms. What are the factors affecting it?
22. Briefly explain the mechanical behavior of metals.

(2 x 5 = 10)

Bunch B: Material Science - II

MAHATMA GANDHI UNIVERSITY

PG-CSS PHYSICS MODEL QUESTION PAPER

Third Semester

Faculty of Science

Physics- Material Science

PH850301: Optoelctronics

(2019 admission onwards)

Time: 3 Hours   Maximum Weight:30

Part A

*Answer any **eight** questions.*

Each question carries 1 weight.

1. Explain Acousto optic effect.
2. Explain Pockel effect.
3. What is meant by Bit rate?
4. Differentiate Surface and Edge emitting LEDs.
5. Explain Laser diode equation.
6. Explain Photo voltaic characteristics.
7. Explain Normalised index difference.
8. Explain V Number of an optical fiber.
9. Explain Dispersion flattened fibres.
10. Explain Ramo's theorem.

(8×1=8)

Part B

*Answer any **six** questions.*

Each question carries 2 weights.

11. A step index fiber has a core diameter of 100µm and a refractive index of 1.480. The cladding has a refractive index of 1.460. calculate numerical aperture, acceptance angle and V number.
12. Calculate the maximum length of an optical fiber whose input power is 1mW and produces an output power of 1 nW with an attenuation coefficient of 0.4 dB km^{-1}.

13. What is the conductivity of an n type Si crystal that has been doped uniformly with 10^{16} cm^{-3} phosphorus atoms if the drift mobility of electrons is about 1350 $cm^2V^{-1}s^{-1}$.
14. A typical low power 5mW He Ne Laser operates at a dc voltage of 2000 V and carries a current of 7 mA. What is the efficiency of the Laser?
15. A Si pin photodiode has an active light receiving area of diameter 0.4 mm. When radiation of wavelength 700nm and intensity 0.1 mW cm^{-1} is incident it generates a photocurrent of 56.6 nA. What is the responsivity and QE of the photodiode at 700 nm?
16. Calculate the slope efficiency of a laser diode operating at 1300 nm, if its external quantum efficiency is 0.1.
17. Estimate the minimum detectable power of a PIN diode whose responsivity and dark current are 0.5 A/W and 1 nA respectively.
18. A GaAs LED has an effective recombination region of width 0.1 μm. If it is operated at a current density of 2 x 10^7 Am^{-2} estimate the modulation bandwidth that can be expected?

(6×2=12)

Part C

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

Each question carries 5 weights.

19. Write a short note on Quantum well lasers and Optical Laser amplifiers.
20. Explain dispersion in single mode fibers.
21. Explain the detection process in Photo conductive detection.
22. Explain the principle and working of Electro optic modulator.

(5×2=10)

MAHATMA GANDHI UNIVERSITY

PG-CSS PHYSICS MODEL QUESTION PAPER

Fourth Semester

Faculty of Science

Physics- Material Science

PH850402: SEMICONDUCTOR DEVICES

(2019 admission onwards)

Time: 3 Hours Maximum Weight:30

Part A

*Answer any **eight** questions.*

Each question carries 1 weight.

1. Write the equation for the total drift current density.
2. State the definition of the quasi-Fermi level for electrons.
3. What is two dimensional electron gas? Explain.
4. Write the characteristics of heterojunction materials.
5. Sketch the electron and hole currents through a forward-biased pn junction diode.
6. What is the cutoff frequency of a bipolar transistor?
7. Obtain the IC technology for resistor formation
8. What is the relation between barrier height, work function and semiconductor electron affinity?
9. Describe the response of a bipolar transistor when it is switching between saturationand cutoff.
10. Write a short note on epitaxial growth.

(8 x 1 = 8)

Part B

*Answer any **six** questions.*

Each question carries 2 weights.

11. What is meant by a short diode?
12. Explain emitter current crowding of bipolar transistor.
13. A uniformly doped n-type silicon epitaxial layer of 0.5Ω-cm resistivity is subjected to boron diffusion with constant surface concentration of 5 x10 ^{18}cm^{-}

^{3}. It is desired to for a p-n junction at a depth of 2.7μm. At what temperature should this diffusion be carried out if it is to be completed in 2hr?

14. Compare the forward-biased current-voltagc characteristic of a Schottky barrier diode tothat of pn junction diode.
15. Sketch the cross section of a diode pair integrated circuit using collector – base region if (a) the cathode is common and (b) the anode is common.
16. Consider n-type *Ge* doped with N_d=10^{16} cm^{-3} and P-type *GaAs* doped with N_a=10^{16} cm^{-3}. Let n_i=2.4 x$10^{13}$$cm^{-3}$ for *Ge* at T=300 K. Determine the difference between two conduction band energies (ΔE_c), difference between two valence band energies (ΔE_v) and the total built in potential barrier V_{bi} for an *n-Ge* to *p-GaAs* hereojunction using the electron affinity rule.
17. Consider a contact between tungsten and n-type silicon doped to N_d=10^{16} cm^{-3} at T=300K. Calculate the theoretical barrier height, built in potential barrier and a maximum electric field in a metal semiconductor diode for zero applied bias. Given, the metal work function for tungsten=4.55V and the electron affinity for silicon is 4.01V.
18. Write a note on Large Scale and Medium Scale Integration.

(6 x 2 = 12)

Part C

*Answer any **two** questions.*

Each question carries 5 weights.

19. Derive the Ambipolar Transport Equation.
20. Explain Ebers-Moll Model of bipolar transistor.
21. Bring out the energy band diagram of hetro junction material and discuss the two dimentional electron gas.
22. Discuss in detail the fabrication of an integrated circuit.

(2 x 5 = 10)

MAHATMA GANDHI UNIVERSITY
PG-CSS PHYSICS MODEL QUESTION PAPER
Fourth Semester
Faculty of Science
Physics- Material Science

PH850403: CERAMICS AND BIO MATERIALS

(2019 admission onwards)

Time: 3 Hours Maximum Weight:30

Part A

*Answer any e**ight** questions.*
Each question carries 1 weight.

1. Explain the structure of a non-oxide ceramics.
2. What is the mechanism behind diffusion in ionic solids?
3. Write down the difference between Ferroelectrics and Piezoelectric
4. What are the significances of Electro-optic ceramics
5. What do you mean by Giant magneto-resistance
6. What are important feature of Magnetic ceramics
7. Explain the principle of protein folding,
8. Write down the major difference in DNA and RNA
9. What are the application of Raman spectroscopy in bioscience
10. Describe the phoneme of magnetic resonance imaging

(8x1= 8)

Part B

*Answer any **six** questions.*

Each question carries 2 weights.

11. Write a note on ionic conductivity in ceramics.
12. Explain the use of Dielectric materials for microwave application.
13. Describe the Thermodynamic formulation of ferroelectrics.
14. Discuss the principle of superconductivity and their applications to high field magnets.
15. What is a Magneto-electronic materials and explain its characteristics?
16. Explain the structure of DNA with neat diagram.
17. Write a note on energy and entropy in complex biomolecules.
18. Explain the working of Transmission electron microscope with a schematic diagram

(6x 2 = 12)

Part C

*Answer any **two** questions.*

Each question carries 5 weights.

19. Explain the frequency dependence of polarization and associated mechanism in electronic ceramics.
20. Describe the Microstructure - property relationships, Applications of piezoelectric materials in transducers
21. Write an essay on molecular modeling of biological problems
22. Explain the principle and working of Nuclear magnetic resonance spectroscopy in Bio materials.

(2 x 5 = 10)

CHAPTER-V
MODEL QUESTION PAPERS

M.Sc PHYSICS DEGREE C.S.S EXAMINATION

1 Semester

Faculty of Science

PH010101 – MATHEMATICAL METHODS IN PHYSICS – I

(2019 Admissions Onwards)

Time : 3 Hrs **Max Weight : 30**

SECTION – A
(Answer Any Eight Questions. Each Question Carries a Weight of 1)

1. State and Prove Gauss' divergence theorm
2. What is similarly transformation? How does it affect the eigen values and eigen vectors of a matrix?
3. State and prove Cayley – Hamiltorn Theorem for square matrices
4. Explain the central limit theorem.
5. Show the Kronecker delta is a mixed tensor of rank 2.
6. State the theorem relating line and surface integrals.
7. What are orthogonal curviliniear co-ordinates?
8. Show that the eigenvalues of Hermitian matrix are orthogonal to each other
9. Explain contra variant and covariant tensors
10. What are Christoffels 3 index symbols? (8 x 1 = 8)

SECTION – B

(Answer Any Six Questions. Each Question Carries a Weight of 2)

11. Solve the system of equations

    $x+y+3z=6$

    $2x+3y-4z=6$

    $3x+2y+7z=0$

12. Show that contraction reduces the rank of a tensor by 2?

13. Discuss the properties of Dirac delta function
14. Discuss Schwartz in equality
15. Define Christoffels symbols of first and second kind
16. Show that in Cartesian co-ordinate system contra variant covariant components of a vector are identical.
17. Discuss the features of linear vector space.
18. Explain Associate Tensors?

(6 x 2 = 12)

SECTION – C

(Answer Any Two Questions. Each Question Carries a Weight of 5)

19. Define general orthogoanal curvilinear co-ordinates and obtain various differential operators in terms of orthogoanal curvilinear co-ordinates
20. Outline the characteristics of Binominal, Poisson and Gaussion distributions
21. What are unitary and Hermitian matrices? State and prove their properties
22. Bringout the transformation laws of Christoffels symbols.

(2 x 5 = 10)

MODEL QUESTION PAPER
M.Sc. DEGRE (PGCSS0EXAMINATION
FIRST SEMESTER
FACULTY OF SCIENCE
Branch II: Physics(A) Pure Physics

PH010102 – CLASSICAL MECHANICS

Time: 3 hours Maximum Weight: 30

PART A

(Answer any **EIGHT** questions. Each question carries **1** weight)

1. Discuss the effect of holonomic constraints on the number of degrees of freedom of a system.
2. What is dissipation function? Give its physical significance.
3. State Noether's theorem.
4. Explain how the Hamiltonian of a system can be generated from its Lagrangian using Legendre transformation.
5. Distinguish between stable equilibrium and unstable equilibrium.
6. Write down the fundamental Poisson brackets.
7. What are the first integrals of a conservative central potential?
8. Explain centrifugal potential in the context of a central force field.
9. Define principal moments of inertia of a rigid body.
10. Explain Thomas precession.

(8 X 1 = 8)

PART B

(Answer any **SIX** questions. Each question carries **2** weight)

11. A bead is sliding on a wire in a uniformly rotating wire in a force free region. The wire is straight and the axis of rotation of the wire is perpendicular to the wire. Obtain the equation of motion of the bead.

12. Derive Hamilton's equations of motion from modified Hamilton's principle.

13. A simple pendulum has a bob of mass $m$with another mass m' at the moving support. Mass m' moves on a horizontal line in the vertical plane containing the bob of the pendulum. Find the normal frequencies and normal modes of vibrations.

14. Show that the transformation $Q = \sqrt{2q}\cos p \ , P = \sqrt{2q}\sin p$ is canonical.

15. Solve the problem of simple harmonic oscillator in one dimension by making use of a canonical transformation.

16. State and prove Poisson's theorem regarding Poisson brackets.

17. A particle falls freely from a height h at a place with latitude λ. Find the deflection due to Coriolis force.

18. Explain the physical significance of Hamilton's principal function.

(6 X 2 = 12)

PART C

(Answer any **TWO** questions. Each question carries 5 weight)

19. Derive Lgrange's equations of motion from Hamilton's principle.

20. Discuss the normal modes and normal coordinates of the free vibrations of CO_2 molecule.

21. Derive Euler's equation for rigid body motion. Apply it to work out the torque free motion of a symmetric top.

22. Describe how action-angle variable can be used to obtain the frequencies of a periodic system without finding a complete solution to the motion of the system. Apply this method to the linear harmonic oscillator problem.

(2 X 5= 10)

MODEL QUESTION PAPER

M.Sc. DEGRE (PGCSS0EXAMINATION

SECOND SEMESTER

FACULTY OF SCIENCE

Branch II: Physics(A) Pure Physics

PH010202 – QUANTUM MECHANICS-I

Time: 3 hours Maximum Weight: 30

PART A

(Answer any **EIGHT** questions. Each question carries **1** weight)

1. Discuss the concept of kets and bras.
2. Show that the outer product of a ket and bra is an operator.
3. What is meant by a Hermitian operator?
4. Define time evolution operator
5. What are energy eigenkets? Why are they called stationary states?
6. State and explain the Ehrenfest's theorem.
7. Give the fundamental commutation relations for angular momentum operators.
8. Write down the rotation operator for a spin half system.
9. Give the matrix elements of J_x and J_y in $|jm\rangle$ basis.
10. Express the L_z operator in spherical polar coordinate system.

(8 X 1 = 8)

PART B

(Answer any **SIX** questions. Each question carries **2** weight)

11. Obtain the matrices representing the three components of spin operator in S_z basis.

12. Show that (a) a change of basis can be accomplished by a unitary transformation. (b)Unitary equivalent observables have identical spectra.

13. Express infinitesimal translation operator in terms of momentum operator. Hence deduce the commutation relation between position and momentum operators.

14. Show that the wavefunctions in momentum space and position space are Fourier transforms of each other.

15. Solve the Schrodinger equation for the time evolution operator for a system with a time independent Hamiltonian.

16. The lifetime of hydrogen in the 2p state to decay to the 1s ground state is 1.6 ns. Calculate the spread in energy of this excited state . Also estimate the linewidth of the emitted spectral line in angstroms.

17. Calculate the commutation relations between all the three pairs of Pauli spin matrices.

18. Calculate the Clebsch-Gordon coefficients associated with the addition of two angular momenta $j_1 = 1/2$; $j_2 = 1/2$.

(6 X 2 = 12)

PART C

(Answer any **TWO** questions. Each question carries 5 weight)

19. State and prove the generalized uncertainty principle.

20. Obtain the energy eigenvalues and energy eigenkets of a simple harmonic oscillator using operator method.

21. Using ladder operators, solve the eigenvalue problem for angular momentum operators.

22. Starting from the Schrodinger equation for a spherically symmetric potential, obtain the energy eigenvalues and the eigenfunctions of the hydrogen atom. Discuss the degeneracy of the energy levels of the hydrogen atom.

(2 X 5= 10)

M Sc (Physics) Degree (C.S.S) Examination,

First Semester

Faculty of Science

Course Code- **PH010103: ELECTRODYNAMICS**

(2019 admissions onwards)

Time: Threehours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. What are the static and dynamic Maxwells equations?
2. What is meant by Maxwells stress tensor? Explain its significance.
3. Why TEM waves can not be transmitted through hollow waveguides?
4. Explain the term characteristic impedance.
5. What is skin depth? How it is related to the attenuation constant?
6. Distinguish between phase velocity and group velocity
7. What is meant by electric dipole radiation?
8. What is a four vector? Give the components of momentum four vector.
9. Explain proper time and proper velocity.
10. What is meant by radiative reaction?

(8 x 1 = 8)

Section B

(Answer any**six** questions. Each question carries a weight of 2)

11. Verify that the Poynting vector is invariant under the transformation **E'** =**E**CosΦ + **B**SinΦ and **B'** = -**E**SinΦ +**B**CosΦ. Give the physical significance of the transformation if Φ= **π**/2
12. Evaluate the magnitude of the current density **J** in a region where the vector potential is given by **A**= x^2**j** - 2xy**k** , where **j** and **k** are unit vectors.

13. Show that $\mathbf{E}^2$-$\mathbf{B}^2$ is Lorentz scalar.
14. Show that **E.B** is relativistically invariant.
15. The lowest frequency of an electromagnetic field is a rectangular waveguide is fixed at 3 MHz. What should be the dimension of the waveguide for its propagation?
16. Show that the power radiated from a magnetic dipole varies as the fourth power of the frequency.
17. Explain Gauss law in dielectric medium
18. For a TE in a rectangular wave guide, show that TE_{10} is the dominant modern

(6 x 2 = 12)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

19. Derive the laws of conservation of energy and momentum in electrodynamics and show that the electromagnetic fields carry energy and momentum
20. Discuss the reflection and transmission of the electromagnetic waves at oblique incidence and obtain the Snell's law.
21. Discuss the propagation of TM waves in rectangular wave guide and obtain an expression for the cutoff frequency
22. Explain retarded potentials. Find the expressions for Lienard-Wiechert potentials.

(2 x 5 = 10)

M.Sc. PHYSICS Degree (C.S.S.) Examination

First Semester

Faculty of Science

PH010104 ELECTRONICS

(2019 admission onwards)

Time: 3hrs

Max.Weight:30

Section A

(Answer any *eight*questions. Each question carriers a weight of 1)

1. Why op-amp called operational amplifier?
2. Using aneat schematic diagram explain how op-amp canbe used asa voltage follower.
3. Discuss current to voltage converter.
4. What are the three methods of compensation?
5. Define slew rate?
6. What is an instrumentation amplifier? Give two applications.
7. What is the principle of phase discriminator?
8. What is a sample and hold circuit? Why is it needed?
9. What is an all pass filter? Where and why is it needed?
10. Write short note on stereo FM reception. (8 x 1 =8)

Section B

(Answer any *sixquestions*. Each question carries a weight of 2)

11. A 5mv, 1 KHz sinusoidal signal is applied to the input of an OP-AMP integrator for which R=100KΏ and c = 1µF. Find the output voltage.
12. Design a Weinbridge oscillator for a frequency of 900Hz.
13. The o/p voltages of a certain OP-AMP circuit changes by 20V in 4µS.What is its Slew rate?
14. Design a second order low pass filter at a high cut off frequency of 1 KHz.
15. Differentiate between inverting and non-inverting amplifiers.
16. With the help of diagram bring out the theory of phase-shift oscillator.
17. Discuss an integrator circuit using Op-Amp.
18. What is the Butterworth response? Explain (6 x 2 =12)

Section C

(Answer any *two*questions. Each question carries a weight of 5)

19. Define a filter? How are filters classified? Explain first order low pass butter worth filter. Discuss its frequency response.

20. With neat circuit diagrams explain the principle and operation of a Square wave generator and a triangular wave generator.

21. What is a comparator? Explain its working. Discuss with theory the working of IC 555 as an astable multivibrator.

22. Compare and contrast voltage to frequency and frequency to voltage converters.

(2x 5 =10)

MODEL QUESTION PAPER
M.SC DEGREE C.S.S EXAMINATION
Semester II
Faculty of Science
PH010201 – MATHEMATICAL METHODS IN PHYSICS – II
(2019 Admissions Onwards)

Time : 3 Hrs **Max Weight : 30**

SECTION – A
(Answer Any Eight Questions. Each Question Carries a Weight of 1)

1. What are analytic functions? Explain.
2. State Cauchy residue theorem.
3. Expand In (1+z) in a Taylor series about z = 0
4. What is infinite Fourier sine and cosine transforms?
5. What is meant inverse Laplace transforms?
6. Show that $P_n(1) = 1$ and $P_n(-1) = (-1)^n$
7. Study the heat equation
8. Show that $H_{2n}(0) = \frac{(-1)^n(2^n)_!}{n!}$
9. Obtain Laplace and Poisson’s equations in Cartesian co-ordinates.
10. Write Helmholtz equation. Give any one application (8 x 1 = 8)

SECTION – B

(Answer Any Six Questions. Each Question Carries a Weight of 2)

11. Show that the real and imaginary parts of the function log *z* satisfy the Cauchy-Riemann equations when z is not zero.
12. Find the residues of $f(z) = \frac{ze^{iz}}{z^4+a^4}$ at its poles.
13. State and prove the convolution theorem.
14. Obtain the Laplace transform of a periodic function with period T.
15. Explain the method of separation of variables
16. Get the general proof of symmetry property of Green's function.
17. Prove that $\beta(\frac{1}{2}, \frac{1}{2}) = \pi$
18. Show that $\Gamma m \Gamma n = \Gamma(m+n)\, \beta(m,n)$ when m>0, n>0 (6 x 2 = 12)

SECTION – C

(Answer Any Two Questions. Each Question Carries a Weight of 5)

19. State and prove Taylors theorem for a complex function.
20. Discuss the properties of Fourier transform.
21. Bring out Green's function and apply it to scattering problem
22. Define Legendre polynomials and prove their orthogonality condition

(2 x 5 = 10)

QP Code: ⋯⋯

M.Sc DEGREE(C.S.S.) EXAMINATION NOVEMBER 2019

Second Semester

Faculty of Science

PH010203 – STATISTICAL MECHANICS

(2019 admission onwards)

Time: Three hours | Maximum Weight : 30

Section A(Answer any **eight** questions. Each carries weight of 1)

1. Explain the thermodynamic and statistical definitions of entropy.
2. How density of states is related to energy for a 2-D system?
3. Explain Gibb's paradox.
4. Obtain the partition function for a system of harmonic oscillators.
5. "The ensemble average of any physical quantity f is identical to the value one expects to obtain on making an appropriate measurement on the given system". Justify this statement.
6. Plot F-D distribution function at $T = 0$ K and $T > 0$ K.
7. What is meant by chemical potential?
8. Explain Fermi temperature and Fermi energy.
9. Discuss the phase separation in mixtures.
10. What is a maxwell construction for van der Waals isotherms?

Section B (Answer any **six** questions. Each question carries weight of 2,)

11. Making use of the fact that the entropy S(N,V,E) of a thermodynamic system is an extensive quantity, show that, $N\left(\frac{\partial S}{\partial N}\right)_{V,E} + V\left(\frac{\partial S}{\partial V}\right)_{N,E} + E\left(\frac{\partial S}{\partial E}\right)_{V,N} = S$
12. For an extreme relativisitic gas, the single-particle energy states is given by $\epsilon(n_x, n_y, n_z) = \frac{hc}{2L}\left(n_x^2 + n_y^2 + n_z^2\right)^{1/2}$, show that, $C_p/C_v = 4/3$.
13. Consider a rigid lattice of distinguishable spin 1/2 atoms in a magnetic field. The spins have two states, with energies $-\mu_0 B$ and $-\mu_0 B$ for spin up and down respectively. The system is at a temperature T. Obtain the heat capacity C_v and schematically plot it as a function of T.
14. Show that chemical potential is the Gibbs free energy per particle($\mu = G/N$).
15. Obtain the density matrix for a system of free particles.
16. Show that the entropy of a system in the grand canonical ensemble can be written as $S = -k\sum_{r,s} P_{r,s} ln P_{r,s}$, where $P_{r,s} = \frac{e^{-\alpha N_r - \beta E_s}}{\sum_{r,s} e^{-\alpha N_r - \beta E_s}}$
17. Derive Clapeyron equation by assuming the Gibbs potential or the chemical potential is same at the phase boundary.
18. Atomic weight of Lithium is $6.94u$ and density $0.53gm/cm^3$. Calculate Fermi energy and Fermi temperature of electrons.

Part C (answer any**two** questions. Each question carries weight of 5.)

19. Derive Liouville's theorem and explain its consequences.
20. Obtain the canonical partition function for system in contact with a thermal reservoir at temperature T.
21. Discuss the density and energy fluctuations in Grand canonical ensemble.
22. Explain the thermodynamic behaviour of an ideal Bose gas.

M.Sc.PHYSICS Degree (C.S.S) Examination

Second Semester

Faculty of Science

PH010204 CONDENSED MATTER PHYSICS

(2019 admissions onwards)

Time: Three hours Max.Weight:30

Section –A

(Answer any Eight questions. Each question carries a weight of 1)

1. What is the difference between optical and acoustic mode?
2. Define density of states.
3. Briefly discuss thermal conductivity of metals.
4. Define phonon momentum.
5. Define the axis vectors of a reciprocal lattice interms of primitive cell lattice vectors.
6. What is a Brillouin zone? Give its construction.
7. Discuss about the different kinds of symmetry shown by crystals.
8. Discuss the phenomenon of antiferro magnetism.
9. How does adiabatic demagnetization produce cooling.
10. Obtain the expression for Lorentz number on the basis of quantum theory

(1x8=8)

Section –B

(Answer any SIX questions. Each question carries a weight of 2)

11. Calculate the glancing angle on the plane (110) of a cube rock salt (a=2.81A^o) corresponding to second order diffraction maximum for the X-rays of wavelength 0.71A^o.
12. Give three differences between dislocations in sc and fcc lattices. Compare both these with dislocations in the bcc lattice.

13. The thermal conductivity of aluminum at 20^{o}C is 210Wm^{-1}K^{-1}. Calculate the electrical resistivity of aluminum at this temperature. The Lorentz number of Aluminum is 2.02x10^{-8}Ωm.

14. The Fermi energy of copper is 7eV. Calculate (a) the Fermi momentum of electron in copper (b) the de Brogile wavelength of the lectron and (c) the Fermi velocity.

15. Prove the in one diamensional diatomic lattice both acoustic and optical brances in dispersion curve mmet the zone boundary normally.

16. Draw temperature dependence of susceptibility of all types of magnetic materials. Comment on them

17. A para magnetic has 10^{28}atoms/m^{3}.. The magnetic moment of each atom is 1.8x10^{-23}Am$^{2.}$ Calculate the paramagnetic susceptibility at 300K. What would be the dipole moment of a bar of this material 0.1m lonf and 1 sq cm cross-section placed in the field of 8x10^{4}A/m.

18. If in a one diamensional lattice, x= M/m<<1, prve that the square of the widths of the optical and acoustic brances are in the ratio x:4

(6x2=12)

Section –C

(Answer any two questions. Each question carries a weight of 5)

19. Explain the Ewald construction. Discuss how reciprocal lattice concept is useful in

X-ray diffraction studies.

20. Discuss Debye model of lattice heat capacity. Derive an expression for it.

21. Discuss Weiss theory of ferro magnetism. Mention its merits and demerits

22. Explain the vibrations of crystal with monoatomic basis. Obtain dispersion relation and discuss first brillouin zone, long wave length limit and phase and group velocities. **(2x5=10)**

MODEL QUESTION PAPER
M.Sc. DEGRE (PGCSS0EXAMINATION
THIRD SEMESTER
FACULTY OF SCIENCE
Branch II: Physics(A) Pure Physics

PH010301 – QUANTUM MECHANICS-II

Time: 3 hours Maximum Weight: 30

PART A

(Answer any **EIGHT** questions. Each question carries **1** weight)

1. Discuss the validity of the WKB method.
2. Give the Bohr-Sommerfeld quantization rule for a potential well.
3. Using WKB, method, obtain the tunneling probability in alpha decay.
4. What is meant by the interaction picture?
5. Give the expression for energy shift in time dependent perturbation.
6. Distinguish between bosons and fermions.
7. Write down the solution of the Klein-Gordon equation for a neutral spin 0 particle.
8. Express the Klein-Gordon equation in the Schrodinger form.
9. What is meant by *zitterbewegung*?
10. Explain how the stability of vacuum is assured in Dirac's theory.

(8 X 1 = 8)

PART B

(Answer any **SIX** questions. Each question carries **2** weight)

11. A particle of charge q that undergoes a simple harmonic is subjected to a constant electric field along the x-direction. Find the first order correction in energy of the particle.

12. Using variational method, estimate the ground state energy of a particle moving under a delta function potential.

13. A particle, which is initially in the ground state of an infinite potential well with walls at x=0 and x=L. It is subjected to a potential $V(t) = V(0)\, e^{-t/\tau}$. Calculate to first order the probability of transition from the ground state to the first excited state. The energies and energy eigenfunctions of the infinite potential well are given by $E_n = \frac{n^2\pi^2\hbar^2}{2mL^2}$; $\psi_n = \sqrt{\frac{2}{L}}\sin\left(\frac{n\pi x}{L}\right)$; $n = 1,2,3 \ldots$

14. Discuss electric dipole approximation.

15. Obtain the relation connecting differential cross section and scattering amplitude

16. Using the Born approximation, calculate the differential cross section for the scattering of an alpha particle of energy 8 MeV from a gold nucleus. Atomic number of helium=2; atomic number of gold=79. Scattering angle = 60^0.

17. Obtain the continuity equation for the Klein-Gordon equation.

18. Prove the anti-commutation relations among Dirac matrices (alpha matrices and beta matrix).

(6 X 2 = 12)

PART C

(Answer any **TWO** questions. Each question carries 5 weight)

19. Develop the degenerate perturbation theory for stationary states and apply it to the first order Stark effect in hydrogen.

20. Derive the expression for total transition probability in case of constant perturbation and obtain Fermi's golden rule.

21. Discuss the partial wave analysis and apply it to the problem of hard sphere scattering.

22. Obtain the non-relativistic limit of the Dirac equation and hence deduce the spin of the Dirac particle.

(2 X 5= 10)

MODEL QUESTION PAPER
M.Sc DEGREE (PGCSS)EXAMINATION
Third Semester
Faculty of Science
Branch II : Physics (A) Pure Physics
PH010302 - Computational Physics
(2019 Admission onward)

Time : Three Hours Maximum Weight 30

Part A

(Answer any Eight Questions. Each question carries 1 weight)

1) What do we understand by the term "First difference of a function y" in case of interpolation? How do we represent it symbolically ? Give one example also.
2) Define cubic spline function and explain its properties
3) A function y= $f(x)$ is tabulated below. Calculate the slope of the function when x =1.4 using Newton's forward difference formula.

x	1.1	1.2	1.4	1.6	1.8	2	2.2
y	2.2783	3.3.3201	4.0552	4.9530	6.0496	7.3891	9.0250

4) Write down the equation we use to integrate a function using Simpson's 3/8 rule and explain each term used.
5) Using Euler method calculate the value of y at t=0.1 in five steps. Given $\frac{dN}{dt}=.5N$ with initial conditions N=10 at t=0.
6) Solve the the following system of equations, x+2y+3=0 ,2x+y=3 using Gauss-Jordan elimination method.
7) Find the inverse of a matrix A= $\begin{bmatrix} 2 & 3 \\ 4 & 5 \end{bmatrix}$ using Gauss-Jordan method
8) Using power method calculate Eigen value and eign matrix of A= $\begin{bmatrix} 2 & 3 & 3 \\ 3 & 3 & 2 \\ 3 & 2 & 3 \end{bmatrix}$
9) Write in short note on how do we obtain Schmidt two level explicit formula
10) Explain what is meant by Buffoon's needle problem

(8X1=8)

Part B

(Answer any Six Questions. Each question carries 2 weight)

11) Water jet from an inclined hose is observed and the height of the water jet h, and horizontal distances x from the tip of the hose are tabulated as shown below. Assuming water follows a parabolic path, fit an appropriate curve and hence calculate the velocity with which water comes out.

x in meter	.1	.15	.2	.25	.3	.35	.4
h in meter	.075	.09375	.1	.09380	.0749	.04375	0

12) By using method of least squares, find the relation of the form $y=ax^b$ to the data tabulated below:

x	2	3	4	5
y	27.8	62.1	110	161

13. The following data gives the melting point of an alloy of lead and zinc where T is the temperature in ^{0}C and P is the percentage of lead in the alloy. Find the melting point of the alloy containing 75% of lead using Newton's interpolation method.

P	60	70	80	90
T	226	250	276	304

14. A river is 100meters wide. Depth, d, at various distances,x, from one bank of the river is tabulated as shown below. With the help of Simpson's 1/3 rule ,calculate the volume of water flowing through the river in one hour when velocity of water flow is 3m/s .

X in meter	0	10	20	30	40	50	60	70	80	90	100
d in meter	0	5	8	9	10	12	9	7	5	2	0

15. Use 4th order R-K method to solve $\frac{dy^2}{dx^2}=x\frac{dy}{dx}+y^2$ Given y(0)=1 , and $\frac{dy}{dx}_{at\ x=0}=2$

Take h=0.2 and find y and y' at x=0.2

16. Find all eigen values and the corresponding eigen vectors of the matrix $\begin{bmatrix} 1 & \sqrt{2} & 2 \\ \sqrt{2} & 3 & \sqrt{2} \\ 2 & \sqrt{2} & 1 \end{bmatrix}$

by Jacobi's method

17. Solve the equation $y'=x^3+y$, with initial condition y(0)=1 to compute y(.02) using Euler's modified formula with h=0.01.
18. Write a short note on using Mote Carlo method for evaluation of integrals.

(6X2=12)

Part C

(Answer any Two Questions. Each question carries 5 weight)

19. Starting from basics deduce Newton's Divided Difference interpolation formula.

20. Obtain the generalised trapezoidal rule of the form.

$\int f(x) = \frac{h}{2} y_0 + y_n + 2(y_1 + y_2 + y_3 + ... + y_{n-1}) + E_n$ through geometrical approach . Write the expression for the error term E_n .

21. Explain why the concept of stability is important in selecting the step size while trying to solve differential equations numerically using Euler's method.
22. Use Crank-Nicholson method to find the numerical solution of the following parabolic partial differential equation after one time step; Tt=Txx; with 0<x<1 ; subjected to the initial condition T(x,0)=1 ,with 0<x<1 and boundary condition T(0,t)=T(1,t)=0 with t>=0. Compute the solution by taking Δt= 1/32.

(2X5=12)

MODEL QUESTION PAPER
M.Sc. DEGRE (PGCSS0EXAMINATION
THIRD SEMESTER
FACULTY OF SCIENCE
Branch II: Physics(A) Pure Physics

PH010303 – ATOMIC AND MOLECULAR PHYSICS

Time: 3 hours Maximum Weight: 30

PART A

(Answer any **EIGHT** questions. Each question carries **1** weight)

1. What is Paschen-Back effect?
2. Explain hyperfine structure in atomic spectral lines?
3. What is the information derivable from the rotational spectrum of a molecule?
4. Explain what is meant by Morse potential.
5. Differentiate between skeletal vibrations and group frequencies.
6. How does the polarizability of a molecule influence its Raman activity?
7. Explain stimulated Raman effect.
8. Distinguish between progressions and sequences.
9. What is meant by chemical shift in NMR spectrum?
10. Explain Fermi contact interaction.

(8 X 1 = 8)

PART B

(Answer any **SIX** questions. Each question carries **2** weight)

11. The term symbol for an atomic state is $^2P_{3/2}$. What are the values of L,S and J for this state? Calculate the Lande' g-factor for this state. What type of Zeeman effect this atom will give?

12.. Derive all possible terms arising out of the combination of an s-electron with a p-electron in LS coupling scheme. Also calculate the separation between singlet state and triplet states.

13.Explain collision broadening and Doppler broadening

14. The rotational constant of $^{1}H^{35}Cl$ is observed to be $10.5909 cm^{-1}$. Determine the value of B for $^{1}H^{37}Cl$ and $^{2}D^{35}Cl$.

15. When H_2 molecule is irradiated with 435.8nm line, the Raman Stoke's vibrational line appear at 18551.05 cm^{-1}. Find the wavenumber of the ant-Stoke's line, the force constant and zero point energy. Atomic weight of hydrogen= 1.008.Avagadro number is 6.023×10^{23} . Obtain the relation connecting differential cross section and scattering amplitude

16. The band origin of a transition in a molecule is observed at 19,378 cm^{-1} . The rotational fine structure indicates that the rotational constants in excited and ground states are 17527 cm^{-1} and 16326 cm^{-1} respectively. Estimate the position of the band head. Which state has larger internuclear distance?

17. Electron spin resonance is observed for atomic hydrogen with an instrument operating at 9.5 GHz. If the g value for the electron in the hydrogen atom is 2.0026, what is the magnetic field applied?

18. Calculate the recoil velocity of a free Mossbauer nucleus of mass $1.67 \times 10^{-25}\ kg.$, when emitting a gamma ray of wavelength 0.1 nm. What is the Doppler shift of the gamma ray to an outside observer?

(6 X 2 = 12)

PART C

(Answer any **TWO** questions. Each question carries 5 weight)

19. Discuss the fine structure of one electron atoms and derive an expression for the fine structure splitting in hydrogen like atoms.

20. Describe the spectrum of a diatomic vibrating rotator assuming Born-Oppenheimer approximation. Discuss the changes in the spectrum when this approximation breaks down

21. Describe how the molecular structure is determined using Raman and IR spectroscopies.

22. Explain the relaxation processes in nuclei and obtain the Bloch equations for the components of nuclear magnetization.

(2 X 5= 10)

M Sc (Physics) Degree (C.S.S) Examination,

Fourth Semester

Faculty of Science

Course Code- **PH010401 NUCLEAR AND PARTICLE PHYSICS**

(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Compare nuclear scattering with optical diffraction.
2. What is meant by isotopic shift? How it is useful in isotope separation.
3. Explain the term electric quadrupole moment.
4. How can you explain the continuous spectrum of β decay?
5. Differentiate between direct reaction and compound nucleus reactions.
6. What is meant by reaction cross section?
7. Why a proton cannot decay except at GUT energies?
8. Explain the role of Higg's mechanism in symmetry breaking of electro-weak interaction
9. Explain 'r process' and 's process'
10. .What are the advantages of carbon dating using accelerator mass spectroscopy technique?

(8 x 1 = 8)

Section B

(Answer any**six** questions. Each question carries a weight of 2)

11. Briefly explain the nuclear force as an exchange force mediated by mesons.
12. Explain the properties of deuteron
13. Explain forbidden β decay
14. A free neutron decays into a proton by the emission of β^- particles of maximum kinetic energy 0.782MeV.If the rest mass of the electron and neutron are 0.0005486u and 1.008665u respectively, find the mass of proton.(1u=931.478MeV)

15. A tritium gas target is bombarded with a beam of monoenergetic protons of kinetic energy 3 MeV to produce He^3 and neutron. What is the kinetic energy of the neutrons emitted at 30^0 to the incident beam?(H^1=1.007276u,n^1=1.008665u,H^3=3.016056u and He^3=3.016030u)
16. Detail the classification of elementary particles.
17. With the help of conservation laws ,determine which of the following reactions are allowed through strong interactions. If they are forbidden, explain why?

 a) $p + p \rightarrow K^+ + \Sigma^+$?
 b) $\pi^- + p \rightarrow n + \gamma$
 c) $p \rightarrow e^+ + \gamma$
 d) $K^0 \rightarrow \pi^- + \pi^+$

18. .What is meant by positron emission tomography.How it can be used in brain scans?

(6 x 2 = 12)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

19. Describe shell model in nuclear physics. How is it successful in explaining parity, magnetic diple moment and quadrupole moment?
20. Explain coulomb scattering and derive differential cross section for elastic coulomb scattering.
21. Explain Quark model. What are the experimental evidences supporting quark model. What is meant by colored quarks and what is its significance?
22. Describe primordial nucleosynthesis

(2 x 5 = 10)

M Sc PHYSICS Degree (C.S.S) Examination

III Semester

Faculty of Science

PH800301 DIGITAL SIGNAL PROCESSING

(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. What you mean by signals? List the classifications of signals.
2. What are FIR and IIR systems?
3. Explain convolution sum.
4. Distinguish between DFT and DTFT.
5. What is decimation in Time? Explain.
6. Define Z-Transform.
7. What is meant by poles and zeros of the system function ?
8. Differentiate between FIR and IIR filter.
9. Obtain window technique.
10. what is direct form I structure of IIR system?

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Describe the advantage limitations and applications of DSP.
12. Explain with examples the different types of operations on signals.
13. Calculate the DFT of the sequence x(n)={1,1,0,0}
14. Explain the computational merits of FFT.
15. Find the Z transform and ROC of the causal sequence x(n)={1,0,3,-1,2}
16. Explain the zeros and poles of system function. Explain the stability criterion related to system function
17. Explain the design of IIR filter using impulse invariance technique
18. Explain the Direct form II realization of digital filters

6 x 2 = 12)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

19. Describe the Classification of discrete time signals with examples.
20. Prove any six properties of DFT
21. Define the Z-transform.What is ROC? What are the properties of ROC?
22. Describe the different methods of realization of digital filters

(2 x 5 = 10)

M.Sc PHYSICS Degree (C.S.S) EXAMINATION

Fourth Semester

Faculty of Science

PH800402- MICROELECTRONICS AND SEMICONDUCTOR DEVICES

(2019 admission onwards)

Time: 3hrs Maximum Weight: 30

Part A

*Answer any **four** questions.*

Each question carries 2 weights.

1. How many clock cycles will be required by 8086 to access a 16 bit word located at an even address?
2. Explain the frequency measurement using microcontroller system.
3. What is two dimensional electron gas? Explain.
4. Write the characteristics of heterojunction materials.
5. Write a note on Cache memory.
6. What are the features of 8051 microcontroller?
7. Obtain the IC technology for resistor formation

(4 x 2 = 8)

Part B

*Answer any **four** questions.*

Each question carries 3 weights.

8. Explain the various addressing modes in 8086 processor.
9. Draw and explain the memory structure of 8085 processor.
10. A uniformly doped n-type silicon epitaxial layer of 0.5Ω-cm resistivity is subjected to boron diffusion with constant surface concentration of 5×10^{18}

cm^{-3}. It is desired to for a p-n junction at a depth of 2.7μm. At what temperature should this diffusion be carried out if it is to be completed in 2hr?

11. Write a programme to sort an array of 6 numbers in ascending order using 8086.
12. How can an I/O pin can be both an input and output in 8051 microcontroller?
13. Consider n-type *Ge* doped with N_d =10^{16} cm^{-3} and P-type *GaAs* doped with N_a=10^{16} cm^{-3}. Let n_i=2.4 x10^{13}cm^{-3} for *Ge* at T=300 K. Determine the difference between two conduction band energies (ΔE_c), difference between two valence band energies (ΔE_v) and the total built in potential barrier V_{bi} for an *n-Ge* to *p-GaAs* hereojunction using the electron affinity rule.
14. Consider a contact between tungsten and n-type silicon doped to N_d =10^{16} cm^{-3} at T=300K. Calculate the theoretical barrier height, built in potential barrier and a maximum electric field in a metal semiconductor diode for zero applied bias. Given, the metal work function for tungsten=4.55V and the electron affinity for silicon is 4.01V.

(4 x 3 = 12)

Part C

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

Each question carries 5 weights.

15. Draw and explain the timing diagram for memory read operation of 8085 processor
16. Draw the 8086 internal architecture and explain.
17. Discuss the instruction set of 8051 microcontroller with appropriate example.
18. Discuss in detail the fabrication of an integrated circuit.

(2 x 5 = 10)

M Sc (Physics). Degree (C.S.S) Examination

Fourth Semester

Faculty of Science

Course Code- PH800403-COMMUNICATION SYSTEMS

(2019 admissions onwards)

Time: Three hours   Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Explain VSAT

2. What is CW Doppler radar

3. Explain GSM

4. State its merits and demerits of PAM

5. Explain the significance of Doppler frequency in RADAR communication

6. Explain total internal reflection

7.What do you mean by guard channel concept?

8.Explain the acceptance angle and numerical aperture for optic fiber.

9. Write a short note on GPS

10.Explain noise in digital data communication.

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. If a signal to interface ratio of 15 KB is required for satisfactory forward channel performance of a cellular system ,What is the frequency use factor and cluster size that should be used for maximum capacity if the path loss exponent is (a) n=4 (b) n=3 ? There are six co-channels in the first tier and all of them are at same distance from the mobile.

12.A silica optical fiber with a core diameter large enough to be considered by ray theory analysis has a core refractive index of 1.50 and a cladding refractive index of 1.47. Determine: (a) the critical angle at the core–cladding interface; (b) the NA for the fiber; (c) the acceptance angle in air for the fiber.

13. Explain the dispersion in fiber optic communication.

14. What are multiplexing techniques? Discuss in detail TDM and FDM.

15.How to improve coverage and capacity of a cellular system?

16. How to improve coverage and capacity of a cellular system?

17. Explain MTI radar.

18. Discuss about digital transmission techniques.

(6 x 2 = 12)

<u>Section C</u>

(Answer any **two** questions. Each question carries a weight of 5.)

19. Explain PCM. What do you mean by quantizing noise? Explain the generation and demodulation of PCM

20. Explain step index and graded index fibers with index profile diagram.

21. What are the multiple access techniques for wireless communication?

22. Derive radar range equation and discuss various target properties.

(2 x 5 = 10)

MSc PHYSICS DEGREE EXAMINATION

III SEMESTER
Faculty of Science

PH810301 SOLID STATE PHYSICS FOR MATERIALS

(2019 admissions onwards)

Time: 3 hours Max. Weight:30

Part A:(Answer any ***eight*** questions. Each question carries a weight of 1)

1. What is polytypism?
2. How do Van der Waals- London interaction evolve?
3. Distinguish between Frenkel and Wannierexcitons?
4. Explain edge dislocation.
5. Discuss the formation of stacking faults in fcc crystals.
6. What is Kirkendall effect?

7. Write a note on plasmons.
8. Explain the role of polarons in crystals.
9. What is polymorphism?
10. State Puling's rules.

(8x1=8)

Part B:(Answer any ***six*** questions. Each question carries a weight of 2)

11. Determine the fraction of atoms in a given solid with energy equal to or greater than 1.4eV at room temperature and 5 times room temperature.
12. Find the radius of the largest sphere that will fit into the void produced by the bcc packing of atoms of radius R.
13. Explain the importance of Born-Haber cycle.
14. Briefly discuss the phase diagram rules.
15. Discuss the role of phase diagram in zone refining of materials.
16. What is LST relation? Explain its importance.
17. What are the different types of diffusion mechanisms? Explain.
18. Assume that the potential energy of two particles in the field of each other is given by $U(R) = -\frac{A}{R} + \frac{B}{R^9}$, where A and B are constants. Show that the particles form a stable compound for $= \left(\frac{9B}{A}\right)^{1/8}$. prove that for stable configuration, the energy of attraction is 9 times the energy of repulsion. Also find the potential energy under stable configuration.

(6x2=12)

Part C:(Answer any ***two*** questions. Each question carries a weight of 5)

19. Explain Madelung energy and evaluate the Madelung constant for a one dimensional chain.
20. Discuss the origin of the quantization of spin waves.
21. What is dislocation and obtain the expression for the energy of dislocation.
22. What are Fick's laws? Obtain the solution for second Fick's law for the diffusion through a plane surface.

(2x5=10)

MSc PHYSICS DEGREE EXAMINATION

IV SEMESTER

Faculty of Science

PH810402 Science of Advanced Materials
(2019 admissions onwards)

Time: 3 hours | Max. Weight:30

Part A:(Answer any ***eight*** questions. Each question carries a weight of 1)

1. What are refractories? List their features.
2. What are semimetals?
3. What do you mean by dielectric breakdown?
4. Mention the properties of Gaussian beams.
5. Distinguish between temporal and spatial coherence.
6. List the features of photonic crystals.
7. Compare SLED and ELED.
8. What is nucleation?
9. What the natures of thin films?
10. Write a note on cathodic sputtering.

(8x1=8)

Part B:(Answer any ***six*** questions. Each question carries a weight of 2)

11. Compare thermoplastic and thermosetting polymers.
12. The tensile strength of 2 PMMA materials are 50MPa and 150MPa. Their respective number average molecular weight in g/mol are 30,000 and 50,000. Estimate the tensile strength at a number average molecular weight of 40,000 g/mol.
13. Show that the photovoltage varies logarithmically with photocurrent.
14. Find the ratio of populations of the two states in a laser that produces a wavelength of 590nm at room temperature.
15. An acousto-optic cell of Raman Nath modulator contains water. A piezoelectric crystal generates an acoustic wave of frequency 5MHz in water. The velocity of the acoustic wave in water is 1500m/s and the thickness of the cell is 1cm. If a laser beam of 632nm is incident on the cell,calculate the angle between the first order diffracted beam and the direct beam.

16. Discuss the classification of liquid crystals.
17. Differentiate between type I and type II superconductors.
18. Explain Josephson tunnelling.

(6x2=12)

Part C:(Answer any ***two*** questions. Each question carries a weight of 5)

19. Discuss the mechanical properties of ceramics.
20. How does mode locking be different from Q-switching? How are they achieved?
21. Explain the solar cell principles and characteristics.
22. Analyse the electrodynamics of superconductors.

(2x5=10)

MSc PHYSICS DEGREE EXAMINATION

IV SEMESTER

Faculty of Science

PH810403 Nanostructures and Materials Characterisation

(2019 admissions onwards)

Time: 3 hours Max. Weight:30

Part A: (Answer any ***eight*** questions. Each question carries a weight of 1)

1. Write a note on quantum dots.
2. What are super lattices?
3. Explain self-assembly.
4. What are the advantages of nanosensors?
5. Why does graphene be important in nanoworld?
6. Distinguish between bathochromic and hypsochromic shifts.
7. What are the features of thermal lens spectroscopy?
8. State and explain Moseley’s law.
9. Define amu and daltons.
10. Why are the applications of TGA more limited than those for DSC?

(8x1=8)

Part B:(Answer any ***six*** questions. Each question carries a weight of 2)

11. Discuss the various steps involve d in a CVD process.
12. Briefly explain the nanolithographic techniques.
13. Describe the features of giant and colossal magnetoresistance.

14. Discuss the size effects in nanostructures.
15. If the molar absorptivity of a complex is 12000 $lmol^{-1}cm^{-1}$ and the minimum detectable absorbance is 0.001, find the minimum molar concentration that can be detected for 1cm path length.
16. What are the advantages of Fourier transform spectrometry?
17. What is the short wavelength limit of the continuum produced by an X-ray tube having silver target and operated at 90kV?
18. An AFM cantilever has a spring constant 0.1N/m. Find its mass if oscillating frequency is 40kHz.

(6x2=12)

Part C: (Answer any ***two*** questions. Each question carries a weight of 5)

19. Discuss the theory of quantum leak.
20. Explain the properties and applications of nano ZnO and TiO_2.
21. (a) Explain how the photoluminescence power is related to concentration. (b) How does the fluorescence lifetime be calculated?
22. Analyse the functioning of TEM and how can you use TEM for quantitative analysis.

(2x5=10)