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

Board of Studies in Physics (P G)

1. Dr.Ambika .K, Associate Professor,Department of Physics, Devaswom Board college, Thalayolaparambu (CHAIRPERSON)
2. Dr. G.Vinod ,Associate Professor,Department of Physics, SreeSankara College, Kalady
3. Sri .Jacob George .Associate Professor,Department of Physics, Government College,Nattakom, Kottayam
4. Dr.Anila.E.I., Associate Professor, Department of Physics, Union Christian College, Aluva.
5. Dr.Jeeju.P.P. Associate Professor, Department of Physics, S.N.M.College Maliankara
6. Sri.Santhosh Jacob, Associate Professor, Department of Physics, Marthoma College Thiruvalla
7. Prof. Mary Jelthruth.K.V, Associate Professor, Department of Physics, St.Pauls College,Kalamassery
8. Dr. Vinu.T.P, Assistant Professor, Department of Physics,,N.S.S. Hindu College ,Changanassery .
9. Dr.Raneesh. B, Assistant Professor, Department of Physics,Catholicate College , Pathanamthitta .
10. Sri.Anand .A , Associate Professor, Department of Physics, M.G. College Thiruvananathapuram.
11. Sri.Prince P.R., Associate Professor, Department of Physics, University CollegeThiruvananathapuram.

ACKNOWLEDGEMENT

The P.G. Board of studies expresses our sincere thanks to the honorable Vice Chancellor of Mahatma Gandhi University, Dr. Sabu Thomas, for the guidance and help extended to us during the restructuring of M.Sc Physics syllabus to suit the Credit and Semester System. The vision and experience in the realm of higher education that he shared with us on various occasions have been helpful and encouraging.

We thank Dr.R.Pragash,(Syndicate Member), for the wholehearted support and for the constant monitoring of the process. His willingness to hear and acknowledge is worth mentioning.

We are highly indebted to Prof..Praveen Kumar V.S.,(Syndicate Member), for his guidance ,support as well as for providing necessary information.

The Board of studies thanks the members of M.G. University syndicate for all the help extended to us at various stages of restructuring of this P G Syllabus.

We thank the Registrar of the university, the Academic Section and the Finance Section for extending their service for the smooth completion of the syllabus restructuring.

Special thanks are due to the representatives from all the colleges affiliated to M.G. University, who have actively participated in the three day work shop. The Board of studies acknowledges the contributions from the participants of the workshop. The suggestions and recommendations of the sub groups formed in the workshop have helped us to make the syllabus in the present form..

We thank Dr. K.P.Satheesh, Visiting Faculty,IIRBS ,M G University and Dr. Jayalakshmi.S,. EmeritusProfessor,Cochin University of Science andTechnology, for the fruitful discussions in the making of the new syllabus.

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 7thedition John Wiley
3. Mathematical Physics, B.S.Rajput,Y.Prakash 9th 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 4thEdn.PHI
2. Electronic Communication Systems, Kennedy& Davis 4thEd.TMH,

Recommended References:

1. Electronic Devices (Electron Flow Version), 9/E Thomas L. Floyd, Pearson
2. Fundamentals of Electronic Devices and Circuits 5th 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 4^{th} 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