CURRICULUM AND SYLLABI

CHOICE BASED CREDIT SYSTEM

(CBCS-PG)

M.Sc. PHYSICS PROGRAMME

INTRODUCED FROM 2016 ADMISSION ONWARDS

BOARD OF STUDIES IN PHYSICS

Sacred Heart College, Thevara, Kochi, Kerala

MSc Physics

SACRED HEART COLLEGE (AUTONOMOUS) –THEVARA, KOCHI -13.
PG PROGRAMME REGULATIONS FOR CHOICE BASED CREDIT SYSTEM 2016

1. **SCOPE**

1.1. These regulations provided here in shall apply to all post-graduate programmes, conducted by Sacred Heart College (S.H.college), Thevara with effect from the academic year 2016-2017 admission onwards.

2. **DEFINITIONS**

2.1 '**Academic Committee'** means the Committee constituted by the principal under this regulation to monitor the running of the Post-Graduate programmes under the Choice Based Credit System (CBCS-PG).

2.2 'Programme' means the entire course of study and examinations.

2.3 '**Duration of Programme'** means the period of time required for the conduct of the programme. The duration of post-graduate programme shall be of 4 semesters.

2.4 **'Semester'** means a term consisting of a minimum of 90 working days, inclusive of examination, distributed over a minimum of 18 weeks of 5 working days, each with 5 contact hours of one hour duration

2.5 **'Course'** means a segment of subject matter to be covered in a semester. Each Course is to be designed variously under lectures / tutorials / laboratory or fieldwork / seminar / project / practical training / assignments / evaluation / Study tour etc., to meet effective teaching and learning needs.

2.6 **'Credit' (Cr)** of a course is the numerical value assigned to a paper according to the relative importance of the content of the syllabus of the programme.

2.7 '**Programme Credit'** means the total credit of the PG Programmes, ie; **80 credits**.

2.8 '**Programme Core course'** Programme Core course means a course that the student admitted to a particular programme must successfully complete to receive the Degree and which cannot be substituted by any other course.

2.9 **'Programme Elective course'** Programme Elective course means a course, which can be chosen from a list of electives and a minimum number of courses is required to complete the programme.

2.10 '**Programme Project'** Programme Project means a regular project work with stated credits on which the student undergo a project under the supervision of a teacher in the parent department / any appropriate Institute in order to submit a dissertation on the project work as specified.

2.11 '**Plagiarism**' Plagiarism is the unreferenced use of other authors' material in dissertations and is a serious academic offence.

2.12 '**Tutorial'** Tutorial means a class to provide an opportunity to interact with students at their individual level to identify the strength and weakness of individual students.

2.13 '**Seminar'** seminar means a lecture expected to train the student in self-study, collection of relevant matter from the books and Internet resources, editing, document writing, typing and presentation.

2.14 '**Evaluation'** means every course shall be evaluated by 25% internal assessment and 75% external assessment.

2.15 '**Repeat course'** is a course that is repeated by a student for having failed in that course in an earlier registration.

2.16 **'Audit Course'** is a course for which no credits are awarded.

2.17 '**Department'** means any teaching Department offering a course of study approved by the college / Institute as per the Act or Statute of the University.

2.18 '**Parent Department'** means the Department which offers a particular Post graduate programme.

2.19 '**Department Council'** means the body of all teachers of a Department in a College.

2.20 **'Faculty Advisor'** is a teacher nominated by a Department Council to coordinate the

continuous evaluation and other academic activities undertaken in the Department.

2.21 '**College Co-ordinator** means a teacher from the college nominated by the College Council to look into the matters relating to CBCS-PG System.

2.22 **'Letter Grade'** or simply '**Grade**' in a course is a letter symbol (S, A, B, C, D, etc.) which indicates the broad level of performance of a student in a course.

2.23 Each letter grade is assigned a **'Grade point'** (GP) which is an integer indicating the numerical equivalent of the broad level of performance of a student in a course.

2.24 **'Credit point'** (CP) of a course is the value obtained by multiplying the grade point (GP) by the Credit (Cr) of the course CP=GP x Cr.

2.25 **'Extra credits'** are additional credits awarded to a student over and above the minimum credits required for a programme for achievements in co-curricular activities carried out outside the regular class hours as directed by the College /Departments.

2.26 '**Semester Grade point average'** (SGPA) is the value obtained by dividing the sum of credit points (CP) obtained by a student in the various courses taken in a semester by the total number of credits taken by him/her in that semester . The grade points shall be rounded off to two decimal places. SGPA determines the overall performance of a student at the end of a semester.

2.27 **Cumulative Grade point average'** (CGPA) is the value obtained by dividing the sum of credit points in all the courses taken by the student for the entire programme by the total number of credits and shall be rounded off to two decimal places.

2.28 '**Grace Marks'** means marks awarded to course/s, as per the orders issued by the college from time to time, in recognition of meritorious achievements in NCC/NSS/Sports/Arts and cultural activities.

2.29 'Words **and expressions'** used and not defined in this regulation but defined in the Mahatma Gandhi University Act and Statutes shall have the meaning assigned to them in the Act and Statute.

3. **ACADEMIC COMMITTEE**

3.1 There shall be an Academic Committee constituted by the principal to manage and monitor the working of (CBCS-PG) 2016.

3.2 The Committee consists of

(a) The principal

(b) The vice principal

(c) Deans of the faculties of science, arts and commerce

(d) The Controller of Examinations

(e) The superintendent of the college

(f) IQAC co-ordinator

4. PROGRAMME STRUCTURE

4.1 Students shall be admitted into post graduate programmes under the various faculties.

4.2 The programme shall include two types of courses, Program Core (C) courses and Program Elective (E) Courses. There shall be a Program Project (D) with dissertation to be undertaken by all students. The Programme will also include assignments, seminars, practical (P), viva (V), Tour / study tour etc., if they are specified in the Curriculum

4.3 There shall be various groups of four Programme Elective courses for a programme such as Group A, Group B etc. for the choice of students subject to the availability of facility and infrastructure in the institution and the selected group shall be the subject of specialization of the programme.

4.4 Project work

4.4.1 Project work shall be completed by working outside the regular teaching hours.

4.4.2 Project work shall be carried out under the supervision of a teacher in the concerned department.

4.4.3. A candidate may, however, in certain cases be permitted to work on the project in an industrial / Research Organization/ Institute on the recommendation of the Supervisor.

4.4.4 There should be an internal assessment and external assessment for the project work in the ratio 1:3

4.4.5 The external evaluation of the Project work is followed by presentation of work including dissertation and Viva-Voce.

4.4.6 The mark and credit with grade awarded for the program project should be entered in the grade card issued by the college.

4.5. **Assignments**: Every student shall submit one assignment as an internal component for every course.

4.6 Seminar Lecture: Every PG student may deliver one seminar lecture as an internal component for every course. The seminar lecture is expected to train the student in self-

study, collection of relevant matter from the books and Internet resources, editing, document writing, typing and presentation.

4.7 Every student shall undergo **two class tests** as an internal component for every course.

4.8 The attendance of students for each course shall be another component of internal assessment.

4.9 Comprehensive Viva-voce shall be conducted at the end semester of the programme which covers questions from all courses in the programme.

5. ATTENDANCE

5.1 The minimum requirement of aggregate attendance during a semester for appearing the end semester examination shall be 75%. Condonation of shortage of attendance to a maximum of 10 days in a semester subject to a maximum of two times during the whole period of Post Graduate programme may be granted by the University college, subject to the recommendation by class-teacher/HOD.

5.2 If a student represents the college in University, State or Nation in Sports, NCC, NSS or Cultural or any other officially sponsored activities such as College union / University union activities, he/she shall be eligible to claim the attendance for the actual number of days participated subject to a maximum of 10 days in a Semester based on the specific recommendations of the Head of the concerned Department and Principal of the College.

5.3 A student who does not satisfy the requirements of attendance shall not be permitted to take the end Semester examinations.

5.4 Those students who are not eligible even with condonation of shortage of attendance shall repeat the course along with the next batch

6. **BOARD OF STUDIES AND COURSES.**

6.1 The Board of Studies concerned shall design all the courses offered in the PG programme. The Boards shall design and introduce new courses, modify or re-design existing courses and replace any existing courses with new/modified courses to facilitate better exposures and training for the students.

6.2 The syllabus of a course shall include the title of the course, contact hours, the number of credits and reference materials.

6.3 Each course shall have an alpha numeric code number which includes abbreviation of

the subject in two letters, the semester number, the code of the course and the serial number of the course ('C' for Program Core course, 'E' for Program Elective course, 'O' for Open Elective course, 'P' for Practical and 'D' for Project/ Dissertation and 'V' for Comprehensive Viva voce).

6.4 Every Programme conducted under Choice Based Credit System shall be monitored by the academic committee and College Council.

7. **REGISTRATION**.

7.1 A student shall be permitted to register for the programme at the time of admission. The duration of the PG Programme shall be 4 semesters.

7.2 A student who registered for the course shall complete the course within a period of 8 continuous semesters from the date of commencement of the programme.

8. **ADMISSION**

8.1 The admission to all PG programmes shall be as per the rules and regulations of the college.

8.2 The eligibility criteria for admission shall be as announced by the college from time to time.

8.3 There shall be provision for inter collegiate and inter University transfer within a period of two weeks from the date of commencement of the semester.

8.4 There shall be provision for credit transfer subject to the conditions specified by the Board of Studies concerned.

9. ADMISSION REQUIREMENTS

9.1 Candidates for admission to the first semester of the PG programme through CBCS shall be required to have passed an appropriate Degree Examination of Mahatma Gandhi University as specified or any other examination of any recognized University or authority accepted by the Academic council of the college as equivalent thereto.

9.2 The candidate must forward the enrolment form to the Controller of Examinations of the college through the Dean / Head of the Department.

9.3 The candidate has to register all the courses prescribed for the particular semester. Cancellation of registration is applicable only when the request is made within two weeks from the time of admission.

9.4 Students admitted under this programme are governed by the Regulations in force.

10. .**PROMOTION**: A student who registers for the end semester examination shall be promoted to the next semester

11. EXAMINATIONS

11.1 There shall be an external examination at the end of each semester.

11.2 The answers must be written in **English** except for those coming under Faculty of languages.

11.3 Practical examinations shall be conducted by the college at the end of the semesters as per the syllabus.

11.4 Project evaluation and Comprehensive Viva –Voce shall be conducted at the end of the programme only. Practical examination, Project evaluation and Comprehensive Viva-Voce shall be conducted by two external examiners.(For professional courses, one examiner can be opted from the same college itself)

11.5 There shall be one end-semester examination of 3 hours duration in each lecture based course (Theory).

11.6 A question paper may contain multiple choice / objective type, short answer type, short essay type questions/problems and long essay type questions. Different types of questions shall have different marks, but a general pattern may be followed by the Board of Studies.

12 **EVALUATION AND GRADING**

12.1 Evaluation: The evaluation scheme for each course shall contain two parts; (a) internal evaluation (ISA) and (b) external evaluation (ESA). 25 marks shall be given to internal evaluation and 75 marks to external evaluation so that the ratio between internal and external mark is 1:3. Both internal and external evaluation shall be carried out in mark system. Both internal and external marks are to be mathematically rounded to the nearest integer.

12.2 Internal evaluation: The internal evaluation shall be based on predetermined transparent system involving periodic written tests, assignments, seminars / viva and attendance in respect of theory courses and based on written tests, lab skill/records/viva and attendance in respect of practical courses. The marks assigned to various components for internal evaluation is as follows.

12.3 Components of Internal Evaluation

All the components of the internal evaluation are mandatory

a) For Theory

	Components	Marks
i.	Assignment	5
ii	Seminar/Viva /Field survey etc.	5
iii	Attendance	5
iv	Two Test papers(2x5)	10
	Total	**25**

b) For Practical

Components	Marks
Attendance	5
Written/Lab test	5
Laboratory Involvement/ punctuality / Record*	10
Viva	5
Total	**25**

*Marks awarded for Record should be related to number of experiments recorded

c) For Project

Components	Marks
Topic/Area selected	2
Experimentation/Data collection	5
Punctuality	3
Compilation	5
Content	5
Presentation	5
Total	**25**

12.4 Evaluation of

Attendance

% of attendance	Mark
Above 90%	5

Between 85 and < 90	4
Between 80 and below 85	3
Between 76 and below 80	2
75	1

Assignment

Components	**Marks**
Punctuality	1
Content	2
Conclusion	1
Reference/Review	1
Total	**5**

Seminar

Components	**Marks**
Content	2
Presentation	2
Reference/Review	1
Total	**5**

Comprehensive Viva

Components	**Marks**
Advanced level questions	1
Masters level questions	2
Basic level questions	2

12.5 To ensure transparency of the evaluation process, the internal assessment marks awarded to the students in each course in a semester shall be published on the notice board at least one week before the commencement of external examination. There shall not be any chance for improvement for internal mark.

12.6 The course teacher and the faculty advisor shall maintain the academic record of each student registered for the course which shall be forwarded to the

controller of examinations through the Principal and a copy should be kept in the college for at least two years for verification.

12.7 External Evaluation: The external examination in theory courses shall be conducted by the college with question papers set by external experts /question bank. The evaluation of the answer scripts shall be done by the examiners based on a well-defined scheme of evaluation given by the question paper setters. The external evaluation shall be done immediately after the examination preferably through the centralised valuation.

12.8 The question paper should be strictly on the basis of model question paper set by BoS with due weightage given for each module of the course and there shall be a combined meeting of the question paper setters and experts for scrutiny and finalisation of question paper. Each set of question should be accompanied by its scheme of valuation.

12.9 For all courses (theory & practical), Letter grades and grade point are given on a 10-point scale based on the total percentage of marks, (ISA+ESA) as given below:-

Percentage of Marks	Grade	Grade Point (GP)
95 and above	O Outstanding	10
85 to below 95	A^+ Excellent	9
75 to below 85	A Very Good	8
65 to below 75	B^+ Good	7
55 to below 65	B Above Average	6
45 to below 55	C Average	5
40 to below 45	D Pass	4
Below 40	F Fail	0
	Ab Absent	0

Grades for the different semesters and overall programme are given based on the corresponding GPA as shown below:

GPA	Grade
Equal to 9.5 and above	***O Outstanding***
Equal to 8.5 and below 9.5	***A+ Excellent***

Equal to 7.5 and below 8.5	***A Very Good***
Equal to 6.5 and below 7.5	***B+ Good***
Equal to 5.5 and below 6.5	***B Above Average***
Equal to 4.5 and below 5.5	***C Average***
Equal to 4.0 and below 4.5	***D Pass***
Below 4.0	***F Failure***

12.10 A **separate minimum of 40% marks** (D grade) required for a pass for both internal evaluation and external evaluation for every course.

12.11 A candidate who has not secured minimum marks/credits in internal examinations can re-do the same registering along with the end semester examination for the same semester, subsequently.

12.12 A student who fails to secure a minimum marks/grade for a pass in a course will be permitted to write the ESA examination along with the next batch.

There will be no improvement examinations

12.13 After the successful completion of a semester, Semester Grade Point Average (SGPA) of a student in that semester is calculated using the formula given below. For the successful completion of semester, a student should pass all courses and score a minimum SGPA of 4.0 However, a student is permitted to move to the next semester irrespective of her/his SGPA.

Credit Point (CP) of a course is calculated using the formula

CP = Cr x GP, where Cr = Credit; GP = Grade point

Semester Grade Point Average (SGPA) of a Semester is calculated using the formula

SGPA = TCP/TCr, where

TCP = Total Credit Point of that semester $= \sum_1^n \mathrm{CPi}$***;***

TCr = Total Credit of that semester $= \sum_1^n \mathrm{Cri}$

Where n is the number of courses in that semester

Cumulative Grade Point Average (CGPA) of a Programme is calculated using the formula

$$\boldsymbol{CGPA} = \sum(\boldsymbol{TCP} \times \boldsymbol{TCr}) \Big/ \sum \boldsymbol{TCr} \quad \boldsymbol{GPA\ shall\ be\ round\ off\ to\ two\ decimal\ places}$$

12.14 PATTERN OF QUESTIONS

Questions shall be set to assess knowledge acquired, standard, application of knowledge, critical evaluation of knowledge and the ability to synthesize knowledge. The question setter shall ensure that questions covering all skills are set. He/She shall also submit a detailed scheme of evaluation along with the question paper.

A question paper shall be a judicious mix of, multiple choice, objective type short answer type, short essay type /problem solving type and long essay type questions.

Pattern of questions for external examination for theory paper

Type of Questions	Total no. of questions	Number of questions to be answered	Marks of each question	Total marks
Section A – multiple choice	5	5	1	05
Section B- Short Answer	10	7	2	14
Section C - Short essay/ Problems	6	4	5	20
Section D - Long essay	6	3	12	36
Grand Total	**27**	**19**		**75**

Pattern of questions for external examination of practical papers will decided by Practical exam board chairman as per the guidelines of Board of Studies.

13. **GRADE CARD**

The colleges under its seal shall issue to the students, a grade card on completion of each semester, which shall contain the following information.

a) Name of the College

b) Title of the Postgraduate Programme

c) Name of the Semester

d) Name and Register Number of the student

e) Code, Title, Credits and Max. Marks (Internal, External & Total) of each course

(theory& Practical) in the semester.

f) Internal, External and Total Marks awarded, Grade, Grade point and Credit point in each course in the semester

g) The total credits, total marks (Max. & Awarded) and total credit points in the semester

h) Semester Grade Point Average (SGPA) and corresponding Grade.

i) Cumulative Grade Point Average (CGPA)

j) The final Mark cum Grade Card issued at the end of the final semester shall contain the details of all courses(theory & practical) taken during the final semester examination and shall include the final grade/marks scored by the candidate from 1st to 3rd semester, and the overall grade/marks for the total programme.

14. **AWARD OF DEGREE**

The successful completion of all the courses with 'D' grade (40%) shall be the minimum requirement for the award of the degree

15**. MONITORING COMMITTEE**

There shall be a Monitoring Committee constituted by the principal consisting of faculty advisors, HODs, Teaching-Learning-Evaluation committee member and college co-ordinator to monitor the internal evaluations conducted by college. The Course teacher, Faculty Advisor, and the College Coordinator should keep all the records of the internal evaluation, for at least a period of two years, for verification.

16. GRIEVENCE REDRESSAL MECHANISM

In order to address the grievance of students regarding Continuous internal assessment (CIA) a three-level Grievance Redressal mechanism is envisaged. A student can approach the upper level only if grievance is not addressed at the lower level.

Level 1: At the level of the concerned course teacher

Level 2: At the level of a department committee consisting of the Head of the Department, a coordinator of internal assessment for each programme nominated by the HoD and the course teacher concerned.

Level 3: A committee with the Principal as Chairman, Dean of the concerned Faculty, HOD of concerned department and one member of the Academic council nominated by the principal every year as members.

17. **TRANSITORY PROVISION**

Notwithstanding anything contained in these regulations, the Principal shall, for a period of three year from the date of coming into force of these regulations, have the power to provide by order that these regulations shall be applied to any programme with such modifications as may be necessary

18. **REPEAL**

The Regulations now in force in so far as they are applicable to programmes offered by the college and to the extent they are inconsistent with these regulations are hereby repealed. In the case of any inconsistency between the existing regulations and these regulations relating to the Choice Based Credit System in their application to any course offered in a College, the latter shall prevail.

Models of distribution of course and credit are given in the following tables.

SEM	Name of the course with course code	No.of Hrs/ week	No. of cred it	Total Credits	Total Hrs/ SEM.
I	**16P1PHYT01:**Mathematical Methods in Physics- I	4	4	15	72
I	**16P1PHYT02**: Classical Mechanics	4	4		72
I	**16P1PHYT03**: Electrodynamics	4	4		72
I	**16P1PHYT04**: Electronics	3	3		54
I	**16P1PHYP01**: General Physics Practical	10	**		180

II	**16P2PHYT05**:Mathematical Methods in Physics- II	4	4	23	72
II	**16P2PHYT06**: Quantum Mechanics - I	4	4		72
II	**16P2PHYT07**: Condensed Matter Physics	4	4		72
II	**16P2PHYT08**: Thermodynamics and Statistical Mechanics	3	3		54
II	**16P2PHYP02**: Electronics Practical General Physics Practical	10	4 4		180
III	**16P3PHYT09**: Quantum Mechanics - II	4	4	15	72
III	**16P3PHYT10**: Computational Physics	4	4		72
III	**16P3PHYT11:** Microelectronics and Semiconductor Devices.	4	4		72
III	**16P3PHYT12:** Integrated Electronics and Digital Signal Processing	3	3		54
III	**16P3PHYP03**: Computational Physics Practical	10	***		180
IV	**16P4PHYT13**: Atomic and Molecular Physics	4	4	27	72
IV	**16P4PHYT14**: Nuclear and Particle Physics	4	4		72
IV	**16P4PHYT15:** Optoelectronics	4	4		72
IV	**16P4PHYT16:** Instrumentation and Communication Electronics	3	3		54
IV	**16P4PHYP04:** Advanced Electronics Practical Computational Physics Practical	10	4 4		180
IV	**16P4PHYPT**: Project/Dissertation	Nil	2		Nil
IV	**16P4PHYCV**: Comprehensive Viva Voce	Nil	2		Nil

Total Credits			80	

** Examination will be conducted at the end of the second semester.

*** Examination will be conducted at the end of the fourth semester

Extra Credits

Study visit to a research lab / industry	1
For undergoing a training with a minimum duration of 40 hours in nonconventional energy sources/energy management	2
	Total extra credits = 3

Table 1

Description of the Evaluation Process- Grade and Grade Point

Percentage of Marks	Grade	Grade Point (GP)
95 and above	O Outstanding	10
85 to below 95	A^+ Excellent	9
75 to below 85	A Very Good	8
65 to below 75	B^+ Good	7
55 to below 65	B Above Average	6
45 to below 55	C Average	5
40 to below 45	D Pass	4
Below 40	F Failure	0
	Ab Absent	0

The Evaluation of each Course comprises of Internal and External Components in the ratio 1:3 for all Courses. Grades and Grade Points are given on a 10-point Scale based on the percentage of Total Marks (Internal + External) as given in Table 1

(Decimals are to be rounded mathematically to the nearest whole number)

Semester Grade Point Average and Cumulative Grade Point Average

Grades for the different Semesters and overall Programme are given based on the corresponding GPA, as shown in Table 2

Table 2

GPA	Grade
Equal to9.5 and above	***O Outstanding***
Equal to 8.5 and < 9.5	***A+ Excellent***
Equal to7.5 and < 8.5	***A Very Good***

SGPA = TCP/TCr, where

TCP = Total Credit Point of that semester $= \sum_1^n \mathrm{CPi}$;

TCr = Total Credit of that semester $= \sum_1^n \mathrm{Cri}$

Where n is the number of courses in that semester

Equal to 6.5 and < 7.5	***B+ Good***
Equal to5.5 and < 6.5	***B Above Average***
Equal to 4.5and < 5.5	***C Average***
Equal to 4.0 and < 4.5	***D Pass***
Below 4.0	***F Failure***

Cumulative Grade Point Average (CGPA) of a Programme is calculated using the formula

$$\boldsymbol{CGPA} = \sum(\boldsymbol{TCP} \times \boldsymbol{TCr}) \Big/ \sum \boldsymbol{TCr}$$

GPA shall be round off to two decimal places

A **separate minimum of 40% marks** (D grade) required for a pass for both internal evaluation and external evaluation for every course

SACRED HEART COLLEGE (AUTONOMOUS)

THEVARA

KERALA

M.Sc. PROGRAMME IN PHYSICS 2016

SEM	Name of the course with course code	No.of Hrs/ week	No. of cred it	Total Credits	Total Hrs/ SEM.
I	**16P1PHYT01:**Mathematical Methods in Physics- I	4	4	15	72
I	**16P1PHYT02**: Classical Mechanics	4	4		72
I	**16P1PHYT03**: Electrodynamics	4	4		72
I	**16P1PHYT04**: Electronics	3	3		54
I	**16P1PHYP01**: General Physics Practical	10	**		180
II	**16P2PHYT05**:MathematicalMethodsinPhysics- II	4	4	23	72
II	**16P2PHYT06**: Quantum Mechanics - I	4	4		72
II	**16P2PHYT07**: Condensed Matter Physics	4	4		72
II	**16P2PHYT08**: Thermodynamics and Statistical Mechanics	3	3		54
II	**16P2PHYP02**: Electronics Practical **16P1PHYP01:** General Physics Practical	10	4 4		180
III	**16P3PHYT09**: Quantum Mechanics - II	4	4	15	72
III	**16P3PHYT10**: Computational Physics	4	4		72
III	**16P3PHYT11:** Microelectronics and Semiconductor Devices.	4	4		72
III	**16P3PHYT12:** Integrated Electronics and Digital Signal Processing	3	3		54

III	**16P3PHYP03**: Computational Physics Practical	10	***		180
IV	**16P4PHYT13**: Atomic and Molecular Physics	4	4	27	72
IV	**16P4PHYT14**: Nuclear and Particle Physics	4	4		72
IV	**16P4PHYT15:** Optoelectronics	4	4		72
IV	**16P4PHYT16:** Instrumentation and Communication Electronics	3	3		54
IV	**16P4PHYP04:** Advanced Electronics Practical **16P3PHYP03**: Computational Physics Practical	10	4 4		180
IV	**16P4PHYPT**: Project/Dissertation	Nil	2		Nil
IV	**16P4PHYCV**: Comprehensive Viva Voce	Nil	2		Nil

Total Credits			80	

** Examination will be conducted at the end of the second semester.

*** Examination will be conducted at the end of the fourth semester

Extra Credits

Study visit to a research lab / industry	1
For undergoing a training with a minimum duration of 40 hours in nonconventional energy sources/energy management	2 Total extra credits = 3

SEMESTER – I

Course code: 16P1PHYT01 **number of credits = 4**

MATHEMATICAL METHODS IN PHYSICS – I **number of Hrs. / Week = 4**

Unit I

Vectors and Vector Spaces (18 Hrs)

Integral forms of gradient, divergence and curl, Line, surface and volume integrals -Stoke's, Gauss's and Green's theorems - Potential theory - scalar, gravitational and centrifugal potentials. Orthogonal curvilinear coordinates - gradient, divergence and curl in Cartesian, spherical and cylindrical co-ordinates. Equation of continuity - Linear vector spaces - Hermitian, unitary and projection operators with their properties- inner product space - Schmidt orthogonalization - Hilbert space - Schwartz inequality.

Text Books

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

Unit II

Matrices (12 Hrs)

Direct sum and direct product of matrices, diagonal matrices, Matrix inversion (GaussJordan inversion method) orthoganal, unitary and Hermitian matrices, normal matrices, Pauli spin matrices, Cayley-Hamilton theorem. Similarity transformation - unitary and orthogonal transformation. Eigen values and eigenvectors – Diagonalisation using normalized eigenvectors. Solution of linear equation-Gauss elimination method. Normal modes of vibrations.

Text Books

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

Probability theory and distributions (6 Hrs)

Elementary probability theory, Random variables, Binomial, Poisson and Gaussian distributions-central limit theorem.

Text Books

1. Mathematical methods for Physics and Engineering, K.F. Riley, M.P Hobson, S. J. Bence, Cambridge University Press (Chapter 24)
2. Mathematical Methods for Physicists, G.B. Arfken &H.J. Weber 4^{th} Edition, Academic Press. (Chapter 19)

Unit III

Differential Geometry (16 Hrs)

Definition of tensors, basic properties of tensors. Covariant, contravariant and mixed tensors. Levi-Civita tensor, Metric tensor and its properties, Tensor algebra, Christoffel symbols and their transformation laws, covariant differentiation, geodesic equation, Riemann-Christoffel tensor, Ricci tensor and Ricci scalar.

Text Books

1. Introduction to Mathematical Physics, Charlie Harper, PHI
2. Vector analysis and tensors, Schaum's outline series, M.R. Spiegel, Seymour Lipschutz, Dennis Spellman, McGraw Hill
3. Mathematical Physics, B.S. Rajput, Y. Prakash 9^{th} Ed, Pragati Prakashan (Chapter10)
4. Tensor Calculus: Theory and problems, A. N. Srivastava, Universities Press

Unit IV

Special functions and Differential equations (20 Hrs)

Gamma and Beta functions, different forms of beta and gamma functions, evaluation of standard integrals. Dirac delta function, Kronecker Delta - properties and applications. Bessel's differential equation – Bessel and Neumann functions – Legendre differential equation - Associated Legendre functions- Hermite differential equation - Laguerre differential equation – Associated Laguerre polynomials. (Generating function, recurrence relations, and orthogonality condition for all functions), Rodrigue's formula

Text Books

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

Reference Books:

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

Course code: 16P1PHYT02 **number of credits = 4**

CLASSICAL MECHANICS **number of Hrs. / Week = 4**

Unit I

Hamiltonian Mechanics (10 Hrs)

Review of Newtonian and Lagrangian formalisms - cyclic co-ordinates - conservation theorems and symmetry properties - velocity dependent potentials and dissipation function - Hamilton's equations of motion - Least action principle - physical significance.

Text Book:

1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3rd Ed., (Chap. 1, 2 & 8)

Variational Principle and Lagrange's equations (6 Hrs)

Hamilton's principle - calculus of variations – examples - Lagrange's equations from Hamilton's principle.

Text Book:

1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3rd Ed., (Chapter 2)

Unit II

Mechanics of Small Oscillations (6 Hrs)

Stable and unstable equilibrium - two-coupled oscillators – Lagrange's equations of motion for small oscillations - normal co-ordinates and normal modes - oscillations of linear tri-atomic molecules.

Text Book:

1. Classical Mechanics, S.L. Gupta, V. Kumar & H.V. Sharma, Pragati Prakashan, 2007(Chapter 8)

Canonical Transformations (7 Hrs)

Equations of canonical transformation- examples of canonical transformation - harmonic oscillator.

Text Book:

1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3rd Ed. (Chapter 9)

Poisson brackets - Lagrange brackets - properties- equations of motion in Poisson bracket form - angular momentum Poisson brackets - invariance under canonical transformations.

Text Book:

1. Classical Mechanics, J.C. Upadhyaya, Himalaya, 2010. (Chapter 7)

Hamilton-Jacobi Theory (7 Hrs)

Hamilton-Jacobi equation for Hamilton's principal function - harmonic oscillator problem - Hamilton - Jacobi equation for Hamilton's characteristic function- action angle variables in systems of one degree of freedom - Hamilton-Jacobi equation as the short wavelength limit of Schrödinger equation.

Text Books:

1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3rd Edn.

2. Classical Mechanics, J.C. Upadhyaya, Himalaya, 2010. (Chapter 8)

Unit III

Central Force Problem (9 Hrs)

Reduction to the equivalent one body problem - equations of motion and first integrals - equivalent one-dimensional problem and classification of orbits - differential equation for the orbits – virial theorem - Kepler problem.

Text Book:

1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3rd Ed.. (Chapter 3)

Rigid Body Dynamics (9 Hrs)

Angular momentum - kinetic energy - inertia tensor - principal axes - Euler's angles- infinitesimal rotations - rate of change of a vector - Coriolis force - Euler's equations of motion of a symmetric top - heavy symmetric top with one point fixed.

Text Book:

1. Classical Mechanics, G. Aruldhas, Prentice Hall 2009, (Chapter 8)

Unit IV

General Theory of Relativity (9 Hrs)

Principle of equivalence - principle of general covariance - motion of a mass point in a gravitational field - the Newtonian approximation - time dilation - rates of clocks in a gravitational field - shift in the spectral lines – energy-momentum tensor- Einstein's field equations and the Poisson approximation.

Text Book:

1. Relativistic Mechanics, Satya Prakash, Pragathi prakashan Pub

Classical Chaos (9 Hrs)

Linear and non-linear systems - integration of linear equation: Quadrature method - the pendulum equation – phase plane analysis of dynamical systems – phase curve of simple harmonic oscillator and damped oscillator- phase portrait of the pendulum - bifurcation - logistic map – attractors -universality of chaos - Lyapunov exponent - fractals - fractal dimension.

Text Book:

1. Deterministic Chaos, N. Kumar, University Press

Reference Books:

1. Classical Mechanics, N.C. Rana and P.S. Joag, Tata Mc Graw Hill
2. Introduction to Classical Mechanics, R.G. Takwale and P.S. Puranik, TMGH.
3. Langrangian and Hamiltonian Mechanics, M.G. Calkin, World Scientific Pub.Co Ltd
4. Introduction to General Relativity, R. Adler, M. Bazin, M. Schiffer, TMGH.
5. An introduction to general relativity, S. K. Bose, Wiley Eastern.
6. The theory of Relativity R.K Pathria Dover Pub. Inc. NY, 2003.
7. Chaos in Classical and Quantum Mechanics, M.C.Gutzwiller, Springer, 1990.
8. Classical Mechanics G. Aruldhas, Prentice Hall 2009,
9. Chaotic Dynamics, G.L.Baker & J.P.Gollub, Cambridge Uni. Press, 1996
10. Mathematical Methods for Physicists, G.B. Arfken &H.J. Weber 4th Edition

16P1PHYT03 **number of credits = 4**

ELECTRODYNAMICS **number of Hrs. / Week = 4**

Unit I

Electrostatic fields in matter and Electrodynamics (10 Hrs)

Review of Electrostatics and Magnetostatics, Time varying fields and Maxwell's equations, differential and integral forms, Potential formulations, Gauge transformations, boundary conditions, wave equations and their solutions, Poynting theorem, Maxwell's stress tensor.

Electromagnetic waves (8 Hrs)

Maxwell's equations in phasor notation. Plane waves in conducting and non-conducting medium, Polarization, Reflection and transmission (Normal and Oblique incidence)

Text Book:

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

Unit II

Relativistic Electrodynamics (18 Hrs)

Structure of space time: Four vectors, Proper time and proper velocity, Relativistic dynamics - Minkowiski force, Magnetism as a relativistic phenomenon, Lorentz transformation of electromagnetic field, electromagnetic field tensor, electrodynamics in tensor notation, Potential formulation of relativistic electrodynamics.

Text Book:

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

Unit III

Electromagnetic Radiation (20 Hrs)

Retarded potentials, Jefimenkos equations, Point charges, Lienard-Wiechert potential, Fields of a moving point charge, Electric dipole radiation, Magnetic dipole radiation, Power radiated by point charge in motion. Radiation reaction, Physical basis of radiation reaction.

Text Book:

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

Unit IV
Antenna, Wave Guides and Transmission Lines (16 Hrs)

Radiation resistance of a short dipole, Radiation from quarter wave monopole or half wave dipole. Antenna parameters. Waves between parallel conducting plane TE, TM and TEM waves, TE and TM waves in Rectangular wave guides, Impossibility of TEM waves in rectangular wave guides. Transmission Lines-Principles-Characteristic impedance, standing waves-quarter and half wavelength lines

Text Books:

1. Electromagnetic waves and radiating systems, E.C. Jordan & K.G. Balmain, PHI, 1968
2. Antennas, J.D Kraus, Tata Mc-Graw Hill.

Reference Books:

1. Antenna and wave guide propagation, K. D Prasad, Satya Prakashan
2. Classical Electrodynamics, J. D. Jackson, Wiley Eastern Ltd.
3. Electromagnetic fields, S. Sivanagaraju, C. Srinivasa Rao, New Age International.
4. Introduction to Classical electrodynamics, Y. K. Lim, World Scientific, 1986.
5. Electromagnetic Waves and Fields, V.V. Sarwate, Wiley Eastern Ltd, New Age Inernational
6. The Feymann Lectures in Physics, Vol. 2, R.P. Feymann, R.B. Leighton & M. Sands.
7. Electronic Communication Systems, G. Kennedy & B. Davis, TMH.

Course Code: 16P1PHYT04 **number of credits = 3**
ELECTRONICS **number of Hrs. / Week = 3**

Unit I

Op-amp with Negative Feedback (13 Hrs)

The operational amplifier-Schematic symbol-The ideal Op-amp-Equivalent circuit of an Op-amp-Ideal voltage transfer curve-Open loop Op-amp configurations-Differential amplifier – Inverting amplifier – Non-inverting amplifier **-**Block diagram representations – Voltage series feedback: Negative feedback – closed loop voltage gain – Difference input voltage ideally zero – Input and output resistance with feedback – Bandwidth with feedback – Total output offset voltage with feedback – Voltage follower. Voltage shunt feedback 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 – Current to voltage converter- Inverter. Differential amplifier with one op-amp and two op-amps.

Text Book:

1. Op-amps and linear integrated circuits, R.A. Gayakwad 4^{th} Edn. PHI, (Chapter 1, 2 & 3)

The Practical Op-amp (6 Hrs)

Input offset voltage –Input bias current – input offset current – Total output offset voltage- Thermal drift – 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.

Text Book:

1. Op-amp and linear integrated circuits, R.A. Gayakwad 4^{th} Ed. PHI. (Chapter 4)

Unit II

General Linear Applications (with design) (12 Hrs)

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

Text Book:

1 Op-amps and linear integrated circuits, R.A. Gayakwad 4th Ed. PHI. (Chap. 6)

Frequency Response of an Op-amp (6 Hrs)

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

Text Book:

1. Op-amps and linear integrated circuits, R.A. Gayakwad 4th Edn.PHI, (Chap.5)

Unit III

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

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

Text Book:

1. Op-amps and linear integrated circuits, R.A. Gayakwad 4th Ed. PHI, (Chap. 7)

Comparators and Converters (5 Hrs)

Basic comparator- Zero crossing detector- Schmitt Trigger – Comparator characteristics- Limitations of op-amp as comparators- Peak detector – Sample and Hold circuit.

Text Book:

1. Op-amps and linear integrated circuits R.A. Gayakwad 4th Edn. PHI. (Chap. 8)

Reference Books:

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.

3. Linear Integrated Circuits and Op Amps, S Bali, TMH

GENERAL PHYSICS PRACTICALS **16P1PHYP01**

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

1. Y, n, σ Cornu's method (a) Elliptical fringes and (b) Hyperbolic fringes.
2. Absorption spectrum –KMnO4 solution / Iodine vapour – telescope and scale arrangement – Hartmann's formula or photographic method
3. Frank and Hertz Experiment – determination of ionization potential.
4. Hall Effect (a) carrier concentration (b) Mobility & (c) Hall coefficient.
5. Resistivity of semiconductor specimen–Four Probe Method.
6. Band gap energy measurement of silicon.
7. Magnetic Susceptibility-Guoy's method / Quincke's method.
8. Michelson Interferometer - λ and dλ / thickness of mica.
9. Ultrasonic-Acousto-optic technique-elastic property of a liquid.
10. B - H Curve-Hysteresis.
11. Oscillating Disc-Viscosity of a liquid.
12. e/m of the electron-Thomson's method.
13. Characteristic of a thermistor - Determination of the relevant parameters.
14. Dielectric constant of a non-polar liquid.
15. Dipole moment of an organic molecule (acetone).
16. Young's modulus of steel using the flexural vibrations of a bar.
17. Verification of Stefan's law and determination of Stefan's constant of radiation
18. Temperature dependence of a ceramic capacitor and verification of Curie-Wiess law
19. Experiments using GM counter- absorption co-efficient of beta rays in materials.
20. Multichannel analyzer for alpha energy determination.

21. Zeeman effect setup – measurement of Bohr magnetron

22. Photoelectric effect – determination of Plank's constant using excel or origin.

23. Magneto-optic effect (Faraday Effect) - rotation of plane of polarization as a function of magnetic flux density.

24. Linear electro-optic effect (Pockels effect) – half wave voltage and variation of intensity with electric field.

25. Silicon diode as a temperature sensor.

26. Electrical and thermal conductivity of copper and determination of Lorentz number.

SEMESTER – II

Course code: 16P2PHYT05 **number of credits = 4**

MATHEMATICAL METHODS IN PHYSICS – II **number of Hrs. / Week = 4**

Unit I

Complex Analysis (18 Hrs)

Functions of a complex variable - Analytic functions - Cauchy-Riemann equation - integration in a complex plane – Cauchy's theorem-deformation of contours - Cauchy's integral formula - Taylor and Laurent expansion-poles, residue and residue theorem – Cauchy's Principle value theorem - Evaluation of integrals.

Text Books:

1. Mathematical Physics, B.D. Gupta, Vikas Pub.House, New Delhi
2. Mathematical methods in Classical and Quantum Physics, T. Dass & S. K. Sharma, Universities Press (2009)
3. Introduction to Mathematical physics, Charlie Harper, PHI

Unit II

Integral Transforms (18 Hrs)

Introduction to Fourier series and Fourier integral form - Fourier transform - square wave, full wave rectifier and finite wave train – momentum representation of hydrogen atom ground state and harmonic oscillator. Laplace transform –inverse Laplace transform-properties and applications – Earth's nutation, LCR circuit, wave equation in a dispersive medium, damped, driven oscillator, solution of differential equations.

Text Books:

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

Unit III

Group theory (18 Hrs)

Introductory definition and concepts of group - point group, cyclic group, homomorphism and isomorphism-classes, reducible and irreducible representations- Schur's Lemmas and Great Orthogonality theorem. Group character table- C2V, C3V and C4V groups, Lie group, concept of generators- rotation group SO(2), SO(3), Unitary Group SU(2) and SU(3) Homomorphism between SU(2) and SO(3) – Irreducible Representation of SU(2).

Text Books:

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

Unit IV

Partial Differential Equations (18 Hrs.)

Characteristics and boundary conditions for partial differential equations. Nonlinear partial differential equations – separation of variables in Cartesian, cylindrical and spherical polar coordinates. Heat equation, Laplace's equation and Poisson's equation. Nonhomogeneous equation - Green's function - symmetry of Green's function - Green's function for Poisson equation, Laplace equation and Helmholtz equation - Application of Green's function in scattering problem

Text Books:

1. Mathematical Methods for Physicists, G.B. Arfken & H.J. Weber 4^{th} Edition, Academic Press.
2. Mathematical Physics, B.S Rajput, Pragati Prakashan

Reference Books:

8. Mathematical Physics, B.D. Gupta, Vikas Pub.House, New Delhi
9. Advanced Engineering Mathematics, E. Kreyszig, 7^{th} Ed., John Wiley
10. Introduction to mathematical methods in physics, G.Fletcher, Tata McGraw Hill
11. Advanced engineering mathematics, C.R. Wylie, & L C Barrett, Tata McGraw Hill

12. Advanced Mathematics for Engineering and Physics, L.A. Pipes & L.R. Harvill, Tata McGraw Hill

13. Mathematical Methods in Physics, J. Mathew & R.L. Walker, India Book House.

14. Mathematical Physics, H.K. Dass, S. Chand & Co. New Delhi.

Course Code: 16P2PHYT06 **number of credits = 4**

QUANTUM MECHANICS – I **number of Hrs. / Week = 4**

Unit I

Basics of Quantum Mechanics (14 Hrs)

Stern - Gerlach experiment leading to vector space concept, Dirac notation for state vectors- ket space, bra space, inner products - algebraic manipulation of operators – unitary operators, eigenkets and eigenvalues – Hermitian operators-concept of complete set-representation of an operator by square matrix – matrix elements of an operator - expectation values of Hermitian and anti-Hermitian operators – generalized uncertainty product –– change of basis-orthonormal basis and unitary matrix, transformation matrixunitary equivalent observables-eigenkets of position-infinitesimal operator and its properties – linear momentum as generator of translation – canonical commutation relations – properties of wave function in position space and momentum space - relations between operator formalism and wave function formalism-momentum operator in position basis – momentum space wave function – computation of expectation values x, x^2, p and p^2 for a Gaussian wave packet.

Text Book:

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

Unit II

Quantum Dynamics (18Hrs)

Time evolution operator and its properties-Schrodinger equation for the time evolution operator - energy eigenkets - time dependence of expectation values - time energy uncertainty relation - Schrodinger picture and Heisenberg picture - behaviour of state kets and observables in Schrodinger picture and Heisenberg picture - Heisenberg equation of motion - Ehrenfest's theorem - time evolution of base kets - transition amplitude - energy eigenket and eigen values of a simple harmonic oscillator using creation and annihilation operators

Text Book:

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

Unit III

Angular momentum (20 Hrs)

Commutation relation between infinitesimal and rotation infinitesimal rotations in quantum mechanics-fundamental commutation relations of angular momentum - rotation operator for spin ½ system - Pauli two component formalism - Pauli spin matrices - 2x2 matrix representation of rotation operator – commutation relations for J^2, Jx – eigenvalues of $J^2$and Jx - matrix elements of angular momentum operators - representation of the rotation operator – rotation matrix-properties of the rotation matrix-orbital angular momentum as a rotation generator - addition of angular momentum and spin angular momentum - addition of spin angular momenta and Clebsch-Gordon coefficients for two spin ½ particles

Text Book:

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

Unit IV

Solutions of Schrodinger equation and Approximation Methods (20 Hrs)

Motion in a central potential - Hydrogen atom problem, WKB approximation - WKB wave function – validity of the approximation - variational methods - bound states – harmonic oscillator - stationary state perturbation theory - non degenerate case .

Text Book:

1. Quantum mechanics, V.K. Thankappan New Age International 1996 (Chapter 4, 8)
2. Quantum Mechanics, G Aruldhas, PHI, 2002, (Chapter 10)

Reference Books:

1. A Modern approach to quantum mechanics, John S. Townsend, Viva Books MGH.
2. Basic Quantum Mechanics, A. Ghatak, Macmillan India 1996
3. Quantum Mechanics, an Introduction, W Greiner, Springer Verlag
4. Quantum Mechanics, E. Merzbacher, John Wiley, 1996
5. Introduction to Quantum Mechanics, D.J. Griffiths, Pearson.

6. Quantum Mechanics, L.I. Schiff, Tata McGraw Hill
7. A Text Book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, TMGH.
8. Quantum Mechanics, Concepts and Applications, N. Zettily, John Wiley & Sons.
9. Fundamentals of Quantum Mechanics Y.R. Waghmare, S Chand & Co.

Course code: 16P2PHYT07 **number of credits = 4**

CONDENSED MATTER PHYSICS **number of Hrs. / Week = 4**

Unit I

Elements of Crystal Structure (6 Hrs)

Review of crystal lattice fundamentals and interpretation of Bragg's equation, Ewald construction, the reciprocal lattice, reciprocal lattice to SC, BCC and FCC lattices, properties of reciprocal lattice, diffraction intensity - atomic, geometrical and crystal structure factors- physical significance.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 8**)**

Free Electron Theory of Metals (12 Hrs)

Review of Drude-Lorentz model - electrons moving in a one dimensional potential well - three dimensional well - quantum state and degeneracy - density of states - Fermi-Dirac statistics - effect of temperature on Fermi-Dirac distribution - electronic specific heat - electrical conductivity of metals - relaxation time and mean free path - electrical conductivity and Ohm's law - Widemann-Franz-Lorentz law - electrical resistivity of metals.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 10**)**

Unit II

Band Theory of Metals (6 Hrs)

Bloch theorem - Kronig-Penney model - Brillouin zone construction of Brillouin zone in one and two dimensions – extended, reduced and periodic zone scheme of Brillouin zone (qualitative idea only) - effective mass of electron - nearly free electron model – conductors - semiconductors - insulators.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 11**)**

Band theory of semiconductors (10 Hrs)

Generation and recombination - minority carrier life-time - mobility of current carriers - drift and diffusion - general study of excess carrier movement- diffusion length. Free carrier concentration in semiconductors - Fermi level and carrier concentration in semiconductors - mobility of charge carriers - effect of temperature on mobility - electrical conductivity of semiconductors - Hall effect in semiconductors.

Text Book:

1. Solid State Physics, S.O. Pillai, New Age International 6th Edn. 2010,(Chapter 10)

Ref. Text:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 13**)**

Unit III

Lattice Dynamics (14 Hrs)

Vibrations of crystals with monatomic basis – diatomic lattice – quantization of elastic waves – phonon momentum.

Text Book:

1. Introduction to Solid State Physics, C. Kittel, 3rd Edn. Wiley India. (Chapter 4).

Anharmonicity and thermal expansion - specific heat of a solid - classical model - Einstein model - density of states - Debye model - thermal conductivity of solids - thermal conductivity due to electrons and phonons - thermal resistance of solids.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 7 &9**)**

Dielectric Properties of Solids (6 Hrs)

Review of basic terms and relations, Ferroelectricity, hysteresis, dipole theory - Curie-Weiss law, classification of ferroelectric materials and piezoelectricity.

Text Book:

1. Solid State Physics, S.O. Pillai, New Age International 6th Edn. 2010, (Chapter 11).

Ferroelectric domain, antiferroelectricity and ferrielectricity.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 14**)**

Unit IV

Magnetic properties of solids (10 hrs)

Review of basic terms and relations, Quantum theory of paramagnetism - cooling by adiabatic demagnetization – Hund's rule – ferromagnetism - spontaneous magnetization in ferromagnetic materials - Quantum theory of ferromagnetism –Weiss molecular field - Curie- Weiss law- spontaneous magnetism - internal field and exchange interaction – magnetization curve – saturation magnetization - domain model.

Text Book:

1. Solid State Physics, S.O. Pillai, New Age International 6th Edn. 2010, (Chapter 9).

Superconductivity (4 Hrs)

Electrodynamics of superconductors- London equations-London equation one dimension-London penetration depth-BCS theory- flux quantization

Text Book:

1. Introduction to Solid State Physics, C. Kittel, 3rd Edn. Wiley India. (Chapter 12).
2. Solid State Physics, S.O. Pillai, New Age International 6th Edn. 2010, (Chapter 8).

Nanotechnology and Metamaterials (Qualitative) (4 Hrs)

Properties of metal, semiconductor, rare gas and molecular nanoclusters-superconducting fullerene-quantum confined materials-quantum wells, wires, dots and rings- metamaterials- graphene

Text Book:

1. Introduction to Nanotechnology, Charles P Poole and Frank J Owens, Wiley India (Chapter 4, 5, 9)

Reference Books:

1. Solid State Physics, N.W. Ashcroft & N.D. Mermin, Cengage Learning Pub.11th Indian Reprint (2011).
2. Solid State Physics, R.L. Singhal, Kedar Nath Ram Nath & Co (1981)
3. Elementary Solid State Physics, M. Ali Omar, Pearson, 4th Indian Reprint (2004).
4. Solid State Physics, C.M. Kachhava, Tata McGraw-Hill (1990).
5. Elements of Solid State Physics, J. P. Srivastava, PHI (2004)
6. Solid State Physics, Dan Wei, Cengage Learning (2008)
7. Solid State Physics, A.J. Dekker, Macmillan & Co Ltd. (1967)

Course Code: 16P2PHYT08 **number of credits = 3**

THERMODYNAMICS AND STATISTICAL MECHANICS **number of Hrs. / Week = 3**

Unit I (18 Hrs)

Introduction to Thermodynamics & Foundations of Statistical Mechanics (12 Hrs)

Laws of thermodynamics; Thermodynamic potentials, Maxwell relations, the approach to equlibrium, Ideas of probability – classical probability – statistical probability – the axioms of probability theory – independent events – counting the number of events – basic ideas of statistical mechanics - definition of the quantum state of the system – simple model of spins on lattice sites – equations of state (Spin system and vacancies in a crystal) – the second law of thermodynamics.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 1, 2, 3 and 4)

The Canonical Ensemble (6 Hrs)

A system in contact with a heat bath – the partition function – definition of the entropy in the canonical ensemble – the bridge to thermodynamics through partition function – condition for thermal equilibrium – thermodynamic quantities from partition function – case of a two level system.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 5)

Unit II (16 Hrs)

The Canonical Ensemble (Continued) (6 Hrs)

Single particle in a one dimensional box – single particle in a three dimensional box – expression for heat and work – rotational energy levels for diatomicmolecules – vibrational energy levels for diatomic molecules – factorizing the partition function – equipartition theorem – minimizing the free energy.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 5)

Statistics of Identical Particles (4 Hrs)

Identical particles – symmetric and antisymmetric wavefunctions - bosons – fermions – calculating the partition function for identical particles – spin – identical particles localized on lattice sites.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 6)

Maxwell Distribution (6 Hrs)

The probability that a particle is in a quantum state – density of states in k space – single particle density of states in energy – distribution of speeds of particles in a classical gas

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition. (Chapter 7)

Unit III (20 Hrs)

Planck's Distribution (5 Hrs)

Blackbody radiation – Rayleigh-Jeans theory – Planck's distribution – derivation of the Planck's distribution – the free energy.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition. (Chapter 8)

Grand Canonical Ensemble (6 Hrs)

Systems with variable number of particles – the condition for chemical equilibrium – the approach to chemical equilibrium – chemical potential – grand canonical ensemble – partition function – grand potential.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M. Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 9)

Fermi and Bose Particles (4 Hrs)

Statistical mechanics of identical particles – thermodynamic properties of a Fermi gas – Non interacting Bose gas.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 10)

Phase Transitions (5 Hrs)

Phases – thermodynamic potential – approximation – first order phase transition - Clapeyron equation – phase separation

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 11)

Reference Books:

1.Statistical Mechanics, R.K. Pathria, & P.D. Beale, 2nd Edn, B-H (Elsevier) (2004).

2. Introductory Statistical Physics, S.R.A. Salinas, Springer (2000).

3. Fundamentals of Statistical and Thermal Physics, F. Rief, McGraw Hill (1986).

4. Statistical Mechanics, Kerson Huang, John Wiley and Sons (2003).

5. Statistical Mechanics, Satyaprakash & Agarwal, Kedar Nath Ram Nath Pub. (2004).

6. Problems and solutions on Thermodynamics and Statistical mechanics, Yung Kuo Lim, World Scientific Pub. (1990)

7. Fundamentals of Statistical Mechanics, A.K. Dasgupta, New Central Book Agency Pub. (2005)

8. Statistical Mechanics: a survival guide, A.M. Glazer and J.S. Wark, Oxford University Press (2001).

ELECTRONICS PRACTICALS **16P2PHYP02**

(Minimum of 12 experiments should be done)

1. R C Coupled CE amplifier - Two stages with feedback - Frequency response and voltage gain.
2. Differential amplifiers using transistors and constant current source - Frequency response, CMRR.
3. Push-pull amplifier using complementary - symmetry transistors-power gain and frequency response.
4. R F amplifier - frequency response & band width - Effect of damping.
5. Voltage controlled oscillator using transistors.
6. Voltage controlled oscillator using IC 555
7. R F Oscillator - above 1 MHz frequency measurement.
8. Differential amplifier - using op-amp.
9. Active filters – low pass and high pass-first and second order-frequency response and rolloff rate.
10. Band pass filter using single op-amp-frequency response and bandwidth.
11. Wein-bridge Oscillator – using op-amp with amplitude stabilization.
12. Op-amp-measurement of parameters such as open loop gain - offset voltage – open loop response.
13. Crystal Oscillator
14. RC phase shift oscillator
15. AM generation and demodulation
16. Solving differential equation using IC 741
17. Solving simultaneous equation using IC 741

18. Current to voltage and voltage to current converter (IC 741)
19. Temperature measurement using ADC and microprocessor.
20. Op-amp-triangular wave generator with specified amplitude.
21. µp - stepper motor control.
22. µp- measurement of analog voltage.
23. µp-Digital synthesis of wave form using D/A Converter.
24. Analog to digital and digital to analog converter ADC0800 & DAC0800

SEMESTER – III

Course Code: 16P3PHYT09 **number of credits = 4**

QUANTUM MECHANICS – II **number of Hrs. / Week = 4**

Unit I

Time Dependent Perturbation Theory (16 hrs)

Time dependent potentials - interaction picture - time evolution operator in interaction picture - time dependent perturbation theory - Dyson series – transition probability - constant perturbation - Fermi-Golden rule - harmonic perturbation - interaction with classical radiation field - absorption and stimulated emission - electric dipole approximation - photo electric effect – energy shift and decay width - sudden and adiabatic approximation.

Text Book:

1. Advanced Quantum Mechanics, J.J. Sakurai, Pearson Education (Chapter 5)
2. Quantum mechanics – V. K. Thankappan New Age Int. Pub 1996 (Chapter 8)

Unit II

Scattering (18 hrs) Asymptotic wave function and differential cross section, Born approximation, Yukawa potential, Rutherford scattering. The partial wave expansion, hard sphere scattering, S-wave scattering for the finite potential well, resonances - Ramsaur- Townsend effect

Text Book:

1. A Modern Approach to Quantum Mechanics, John S. Townsend, Viva Books Pvt Ltd, MGH (Chapter 13)

Unit III

Relativistic Quantum Mechanics (18 hrs)

Need for relativistic wave equation - Klein-Gordon equation - Probability conservation - covariant notation - derivation of Dirac equation - conserved current representation - large and small components - approximate Hamiltonian for electrostatic problem - free particle at rest -plane wave solutions - gamma matrices– relativistic covariance of Dirac equation - angular momentum as constant of motion.

Text Book:

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

Unit IV

Elements of Field Theory (20 hrs)

Euler-Lagrange equation for fields - Hamiltonian formulation – functional derivatives conservation laws for classical field theory - Noether's theorem - Non relativistic quantum field theory - quantization rules for Bose particles, Fermi particles - relativistic quantum field theory - quantization of neutral Klein Gordon field (briefly) - canonical quantization of Dirac field – plane wave expansion of field operator - positive definite Hamiltonian.

Text Book:

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

Reference Books:

(In addition to books given under PH2C06, the following books are also recommended)

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

Course Code: 16P3PHYT10 **number of credits = 4**

COMPUTATIONAL PHYSICS **number of Hrs. / Week = 4**

Unit I

Curve Fitting and Interpolation (20Hrs)

The least squares method for fitting a straight line, parabola, power and exponential curves with the help of principle of least square fit. Interpolation - Introduction to finite difference operators, Newton's forward and backward difference interpolation formulae, Lagrange's interpolation formula, Newton's divided difference formula with error term, interpolation in two dimensions. Cubic spline interpolation end conditions, cubic spline method -finding maxima and minima of a tabulated function Statistical tests – Ψ square test and T-test.

Unit II

Numerical Differentiation and Integration (16 Hrs)

Numerical differentiation, errors in numerical differentiation, Integration of a function with Trapezoidal Rule, Simpson's 1/3 and 3/8 Rule and error associated with each. Romberg's integration, Gaussian integration method, Basic idea to Monte Carlo evaluation of integrals

Unit III

Numerical Solution of Ordinary Differential Equations (20Hrs)

Euler method - modified Euler method and Runge - Kutta 4 order methods – adaptive step size R-K method, predictor - corrector methods - Milne's method, Adam-Mouton method. Numerical Solution of System of Equations Gauss-Jordan elimination Method, Gauss-Seidel iteration method, Gauss elimination method and Gauss-Jordan method to find inverse of a matrix. Power method and Jacobi's method to solve eigenvalue problems.

Unit IV

Numerical solutions of partial differential equations (16Hrs)

Elementary ideas and basic concepts in finite difference method, Schmidt Method, Crank - Nicholson method, Weighted average implicit method. Concept of stability.

Text Books:

1. Mathematical Methods, G. Shanker Rao, K. Keshava Reddy, I.K. International Publishing House, Pvt. Ltd.

2. Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd.

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.K Iyengar, 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, 4th Edn, 1958

ELECTIVES

Course Code: 16P3PHYT11 **number of credits = 4**

MICROELECTRONICS AND SEMICONDUCTOR DEVICES **number of Hrs. / Week = 4**

Unit I

Introduction to microprocessors (18 Hrs)

Microcomputer hardware system – memory organization – main memory array – memory management – cache memory - input/output - standard I/O – memory mapped I/O – microcomputer I/O circuits – interrupt driven I/O –DMA, Coprocessors. 8085 Microprocessor architecture, addressing modes, instruction set, simple programming concepts

Unit II

8086 Microprocessor (19 Hrs)

The Intel 8086 - architecture – system design using - 8086 addressing modes - instruction set-instruction format - Programming with 8086 - interfacing memory and I/O ports - Intel 8087.

Unit III

Microcontrollers (19 Hrs)

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

Unit IV

Semiconductor Devices (16 hrs)

Schottky barrier diode - qualitative characteristics – ideal junction properties – nonlinear effects on barrier height – current voltage relationship – comparison with junction diode – metal semiconductor ohmic contact – ideal non rectifying barriers – tunnelling barrier – specific contact resistances – hetro-junctions – hetro junction materials – energy band diagram – two dimensional electron gas – equilibrium electrostatics – current voltage characteristics

Text Books

1. Microprocessors and Microcomputer based system design, H. Rafiquizzaman, Universal Book stall, New Delhi
2. Microprocessor and Peripherals, S.P. Chowdhury & S. Chowdhury-SCITECH Publications
3. Microprocessor Architecture Programming and Applications with 8085, R.S. Gaonkar – Penram int. Pub. Mumbai
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

Reference Books:

1. 0000 to 8085 Introduction to Microprocessors for Engineers and Scientists.- P.K. Gosh & P.R. Sridhar, PHI
2. Advanced microprocessors and peripherals, A.K. Ray & K.M. Burchandi –TMH.
3. Microprocessor and microcontroller, R. Theagarajan- SCITECH Publications India Pvt. Ltd.
4. Operating system Principles, Abraham Silberschatz & Peter Baer Galvin & Greg Gagne, John Wiley

ELECTIVES

Course Code: 16P3PHYT12 **number of credits = 3**

INTEGRATED ELECTRONICS AND DIGITAL SIGNAL PROCESSING **number of Hrs. / Week = 3**

Unit I

Integrated Circuit Fabrication and Characteristics (16 Hrs)

Integrated circuit technology – basic monolithic IC – epitaxial growth – marking and etching – diffusion of impurities – transistor for monolithic circuit – monolithic diodes – integrated resisters, capacitors and inductors – monolithic circuit layout - additional isolation methods – MSI, LSI, VLSI (basic ideas) – the metal semiconductor contact.

Unit II

Basics of Digital Signal Processing (18 Hours)

Signals and representation – classification - continuous time (CT) and discrete time (DT) signals - standard CT and DT signals - Fourier Analysis of periodic and aperiodic continuous time signals - convolution and correlation of DT and CT Signals – classification of systems CT – DT - causal, noncausal, static and dynamic systems - stable systems - FIR and IIR systems -frequency domain representation of systems

Unit III

DSP Techniques (18 Hrs)

Frequency analysis of DT signals - discrete Fourier Transform - Fast Fourier Transform (FFT) - Decimation in time and decimation in frequency algorithm - Z-Transform regional convergence and properties - relation to Fourier Transform - Poles and Zeros of system function - Gibb's phenomenon

Text Books

1. Integrated Electronics – Analog and Digital Circuits and Systems, J. Millmann & C.C. Halkias, TMGH

2. Digital Signal Processing: Theor, Analysis and Digital-Filter Design, B. Somanathan Nair, PHI (2004)

3. Digital Signal Processing, P. Ramesh Babu, Scitech

4. Digital Signal Processing, Alan V. Oppenheim & R.W. Schafer, PHI

Reference Books:

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

Course Code: 16P3PHYP03

COMPUTATIONAL PHYSICS PRACTICALS

(Minimum of 12 Experiments should be done with C++ / FORTRAN as the programming language)

1. Study the motion of a spherical body falling through a viscous medium and observe the changes in critical velocity with radius, viscosity of the medium.

2. Study the path of a projectile for different angles of projection. From graph find the variation in range and maximum height with angle of projection.

3. Study graphically the variation of magnetic field B(T) with critical temperature in superconductivity using the relationship $B(T) = B0 [1 - (T/Tc)]$, for different substances.

4. Discuss the charging /discharging of a capacitor through an inductor and resistor, by plotting time –charge graphs for a) non oscillatory, b) critical) oscillatory charging.

5. Analyse a Wheatstone's bridge with three known resistances. Find the voltage across the galvanometer when the bridge is balanced.

6. Sudy the variation in phase relation between applied voltage and current of a series L.C.R circuit with given values of L C nd the resonant frequency and maximum current.

7. A set of observations of π meson disintegration is given. Fit the values to a graph based on appropriate theory and hence calculate life time τ of π mesons.

8. Draw graphs for radioactive disintegrations with different decay rates for different substances. Also calculate the half-life's in each case.

9. Half-life period of a Radium sample is 1620 years. Analytically calculate amount of radium remaining in a sample of 5gm after 1000 years. Varify your answer by plotting a graph between time of decay and amount of substance of the same sample.

10. Plot the trajectory of a α-particle in Rutherford scattering and determine the values of the impact parameter.

11. Draw the phase plots for the following systems.

    (i) A conservative case (simple pendulum)

    (ii) A dissipative case (damped pendulum)

    A nonlinear case (coupled pendulums).

12. Two masses m1 and m2 are connected to each other by a spring of spring constant k and the system is made to oscillate as a two coupled pendulum. Plot the positions of the masses as a function of time.

13. Plot the motion of an electron in (i) in uniform electric field perpendicular to initial velocity (ii) uniform magnetic field at an angle with the velocity and (iii) simultaneous electric and magnetic fields in perpendicular directions with different field strengths.

14. A proton is incident on a rectangular barrier, calculate the probability of transmission for fixed values of V0 and E (V0 > E) for the width of barrier ranges from 5 to 10 Fermi, and plot the same.

15. Generate the interference pattern in Young's double slit-interference and study the variation of intensity with variation of distance of the screen from the slit.

16. Analyze the Elliptically and circularly polarized light based on two vibrations emerging out of a polarizer represented by two simple harmonic motions at right angles to each other and having a phase difference. Plot the nature of vibrations of the emergent light for different values of phase difference

17. Generate the pattern of electric field due to a point charge

18. Sketch the ground state wave function and corresponding probability distribution function for different values of displacements of the harmonic oscillator.

19. Gauss elimination method for solving a system of linear equations.

20. Solving a second order differential equation using 4^{th} order Runge- Kutta method.

21. Finding the roots of a nonlinear equation by bisection method.

22. Ising Model simulation

23. Least square fitting

24. Radom walk

Reference Books:

1. Computational physics, An Introduction, R.C. Verma, P.K. Ahluwalia &
2. K.C. Sharma, New Age India, Pvt. Ltd. An Introduction to computational Physics, Tao Pang, Cambridge University Press.
3. Simulations for Solid State Physics: An Interactive Resource for Students and Teachers, R.H. Silsbee & J. Drager, Cambridge University Press.
4. Numerical Recipes: the Art of Scientific Computing, W.H. Press, B.P.
5. Flannery, S.A. Teukolsky & W.T.Vettering, Cambridge University Press.

SEMESTER – IV

Course Code: 16P4PHYT13 **number of credits = 4**

ATOMIC AND MOLECULAR PHYSICS **number of Hrs. / Week = 4**

Unit I

Atomic Spectra (18 Hrs)

The hydrogen atom and the three quantum numbers *n*, *l* and *ml.* - electron spin - spectroscopic terms. Spin-orbit interaction, derivation of spin-orbit interaction energy, fine structure in sodium atom, selection rules. Lande g-factor, normal and anomalous Zeeman effects, Paschen–Back effect and Stark effect in one electron system. L S and j j coupling schemes (vector diagram) - examples, derivation of interaction energy, Hund's rule, Lande interval rule. Hyperfine structure and width of spectral lines. (qualitative ideas only).

Text Book:

1. Spectroscopy, B.P. Straughan & S. Walker, Vol. 1, John Wiley & Sons

Unit II

Microwave and Infra-Red Spectroscopy (18 Hrs.)

Microwave Spectroscopy: Rotational spectra of diatomic molecules - intensity of spectral lines - effect of isotopic substitution. Non–rigid rotor - rotational spectra of polyatomic molecules - linear and symmetric top - Interpretation of rotational spectra.

IR Spectroscopy: Vibrating diatomic molecule as anharmonic oscillator, diatomic vibrating rotor – break down of Born-Oppenheimer approximation - vibrations of polyatomic molecules - overtone and combination frequencies - influence of rotation on the spectra of polyatomic molecules - linear and symmetric top - analysis by IR technique - Fourier transform IR spectroscopy.

Text Books:

1. Fundamentals of molecular spectroscopy, C.N. Banwell, Tata McGraw Hill
2. Molecular structure and spectroscopy, G. Aruldhas, PHI Learning Pvt. Ltd.

Unit III

Raman and Electronic Spectroscopy. (18 Hrs)

Raman Spectroscopy: Pure rotational Raman spectra - linear and symmetric top molecules - vibrational Raman spectra – Raman activity of vibrations - mutual exclusion principle - rotational fine structure - structure determination from Raman and IR spectroscopy. Non- linear Raman effects - hyper Raman effect - classical treatment - stimulated Raman effect – Resonant Raman scattering, CARS, PARS - inverse Raman effect

Electronic Spectroscopy: Electronic spectra of diatomic molecules - progressions and sequences - intensity of spectral lines. Franck – Condon principle - dissociation energy and dissociation products - Rotational fine structure of electronic-vibrational transition - Fortrat parabola - Pre-dissociation.

Text books:

1. Fundamentals of molecular spectroscopy, C.N. Banwell, MGH
2. Molecular structure and spectroscopy, G. Aruldhas, PHI Learning Pvt. Ltd.
3. Lasers and Non-Linear Optics, B.B Laud, Wiley Eastern

Unit IV

Spin Resonance Spectroscopy (18 Hrs)

NMR: Quantum mechanical and classical descriptions - Bloch equations - relaxation processes - chemical shift - spin–spin coupling - applications of NMR.

ESR: Theory of ESR - thermal equilibrium and relaxation - g- factor - hyperfine structure -applications.

Mossbauer spectroscopy: Mossbauer effect - recoilless emission and absorption - hyperfine interactions – chemical isomer shift - magnetic hyperfine and electronic quadrupole interactions - applications.

Text Book:

1. Molecular structure and spectroscopy, G. Aruldhas, PHI Learning Pvt. Ltd.
2. Spectroscopy, B.P. Straughan & S. Walker, Vol. 1, John Wiley & Sons

Reference Books:

1. Introduction of Atomic Spectra, H.E. White, Mc Graw Hill
2. Spectroscopy (Vol. 2 & 3), B.P. Straughan & S. Walker, Science 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. Molecular Spectra and Molecular Structure, Vol. 1, 2 & 3. G. Herzberg, Van Nostard, London.
6. Elements of Spectroscopy, Gupta, Kumar & Sharma, Pragathi Prakshan
7. The Infra Red Spectra of Complex Molecules, L.J. Bellamy, Chapman & Hall. Vol. 1 & 2.
8. Laser Spectroscopy techniques and applications, E.R. Menzel, CRC Press, India

Course Code: 16P4PHYT14 **number of credits = 4**

NUCLEAR AND PARTICLE PHYSICS **number of Hrs. / Week = 4**

Unit I

Nuclear Properties and Force between Nucleons (18 Hrs)

Nuclear radius, mass and abundance of nuclides, nuclear binding energy, nuclear angular momentum and parity, nuclear electromagnetic moments, nuclear excited states Duetron, nucleon-nucleon scattering, proton-proton and neutron-neutron interactions, properties of nuclear forces, exchange force model

Text Book:

1. Introductory Nuclear Physics, K. S. Krane Wiley, (Chapter 3&4)

Unit II

Nuclear Decay and Nuclear Reactions (18 Hrs)

Beta decay, energy release, Fermi theory, experimental tests, angular momentum and parity selection rules, Comparative half-lives and forbidden decays, neutrino physics, non-conservation of parity, Types of reactions and conservation laws, energetics of nuclear reactions, isospin, Reaction cross sections, Coulomb scattering, nuclear scattering, scattering and reaction cross sections, compound-nucleus reactions, direct reactions, heavy ion reactions.

Text Book:

1. Introductory Nuclear Physics, K. S. Krane Wiley, (Chapter 9&11)

Unit III

Nuclear Models, Fission and Fusion (18 Hrs)

Shell model potential, Spin-orbit potential, Magnetic dipole moments, Electric quadrupole moments, Valence Nucleons, Collective structure, Nuclear vibrations, Nuclear rotations, Liquid drop Model, Semi-empirical Mass formula Characteristics of fission - energy in fission - fission and nuclear structure, Controlled fission reactions - Fission reactors. Fusion processes, Characteristics of fusion, Controlled fusion reactors

Text Book:

1. Introductory Nuclear Physics, K. S. Krane Wiley, (Chapter 5, 13 &14)

Unit IV

Particle Physics (18 Hrs)

Types of interactions between elementary particles, Hadrons and leptons-masses, spin, parity and decay structure. Quark model, confined quarks, coloured quarks, experimental evidences for quark model, quark-gluon interaction. Gell-Mann-Nishijima formula, symmetries and conservation laws, C, P and T invariance, applications of symmetry arguments to particle reactions, parity non-conservation in weak interactions. Grand unified theories.

Text Book:

1. Introductory Nuclear Physics, K. S. Krane Wiley, (Chapter 18)

2. Nuclear Physics, D. C. Tayal, Himalaya Publishing House (Chapter 16)

Reference Books:

1. Introduction to Elementary Particle, D.J. Griffiths, Harper and Row, NY,(1987)
2. Nuclear Physics, R.R. Roy and B.P. Nigam, New Age International, New Delhi, (1983).
3. The particle Hunters - Yuval Ne'eman & Yoram kirsh CUP, (1996)
4. Concepts of Nuclear Physics, B.L. Cohen, TMH, New Delhi, (1971).
5. Theory of Nuclear Structure, M.K. Pal, East-West, Chennai, (1982).
6. Atomic Nucleus, R.D. Evans, McGraw-Hill, New York.
7. Nuclear Physics, I. Kaplan, 2nd Edn, Narosa, New Delhi, (1989).
8. Introduction to Nuclear Physics, H.A. Enge, Addison Wesley, London, (1975).
9. Introductory Nuclear Physics, Y.R. Waghmare,Oxford-IBH, New Delhi, (1981).
10. Atomic and Nuclear Physics, Ghoshal,Vol. 2, S. Chand & Company
11. Fundamentals of Elementary Particle Physics, J.M. Longo, MGH, New York, (1971).
12. Nuclear and Particle Physics, W.E. Burcham and M. Jobes, Addison-Wesley, Tokyo, (1995).

13. Subatomic Physics, Frauenfelder and Henley, Prentice-Hall.

14. Particles and Nuclei: An Introduction to Physical Concepts, B. Povh, K. Rith, C. Scholz and Zetche, Springer (2002).

15. Elementary Particles and Symmetries, L.H. Ryder, Gordon and Breach, Science Publishers, NY, 1986

OPTIONAL ELECTIVE BUNCH

Course Code: 16P4PHYT15 **number of credits = 4**

OPTOELECTRONICS **number of Hrs. / Week = 4**

Unit I

Semiconductor Science and Light Emitting Diodes (10 hrs)

Semiconductor Science

Semiconductor energy bands - semiconductor statistics – extrinsic semiconductors – compensation doping – degenerate and non-degenerate semiconductors – direct and indirect bandgap semiconductors. Radiative and nonradiative recombination and recombination rates. Absorption in semiconductors – indirect transitions, exciton absorption, donor- acceptor band impurity band absorption. Long wavelength absorption. Franz Keldysh effect.

LED (light emitting diodes)

Principles - device structures - LED materials, heterojunction high intensity LEDs – double heterostructure – LED characteristics.LEDs for optical fiber communications - surface and edge emitting LEDs. Applications &advantages.

Text Book

1. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson 2009,
2. Semiconductor optoelectronic devices – Pallab Bhattacharya PHI

Fiber Optics (10 Hrs)

Symmetric planar dielectric slab waveguide – waveguide condition – single and multimode waveguides – TE and TM modes – modal and waveguide dispersion in the planar waveguide – dispersion diagram – intermodal dispersion – intramodal dispersion – dispersion in single mode fibers – material dispersion – waveguide dispersion – chromatic dispersion – profile and polarization dispersion – dispersion flattened fibers - – graded index optical fiber -– attenuation in optical fibers.

Text Book:

1. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson (2009), (Refer Chapter 2)

Unit II

Laser Principles (10 hrs)

Laser oscillation conditions - diode laser principles – homojunction laser diode and thresh hold current density- heterostructure laser diode – double heterostructure and its advantages – stripe geometry – buried heterostructure – gain and index guiding - laser diode characteristics – laser diode equation - single frequency solid state lasers – distributed feedback –quantum well lasers - vertical cavity surface emitting laser - optical laser amplifiers.

Text Book:

1. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson (2009), (Chapter 4)

Laser Output Control (6 hrs)

Generation of high power pulses, Q-factor, Q-switching for giant pulses and its theory, methods of Q-switching, mode locking and its theory - techniques for mode locking.

Text Book:

1. Laser fundamentals, William T. Silfvast, CUP 2nd Edn. (2009), (Chapter 13)

Unit III

Photodetectors and Photovoltaics (18 hrs)

Ramo's theorem and external photocurrent - absorption coefficient and photodiode materials - quantum efficiency and responsivity - PIN-photodiode – avalanche photodiode – phototransistor - photoconductive detectors and photoconductive gain - noise in photo-detectors – noise in avalanche photodiode - solar energy spectrum - photovoltaic device principles – I-V characteristics - series resistance and equivalent circuit - temperature effects - solar cell materials, device and efficiencies

Text Book

1. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson (2009), (Chapter 5 & 6)

Unit IV

Optoelectronic Modulators (10 Hrs)

Electro-optic modulators – Pockels effect - longitudinal and transverse electro-optic modulators, Kerr effect, Magneto-optic effect, acousto-optic effect – Raman Nath and Bragg-types.

Text Books:

1. Fiber optics and Optoelectronics, R.P. Khare, Oxford University Press, (2004)(Chapter 9)
2. Optoelectronics: an Introduction, J. Wilson and J.F.B. Hawkes, PHI, (2000), (Chapter 3)

Non-linear Optics (8 Hrs)

Wave propagation in an anisotropic crystal - polarization response of materials to light - second order non-linear optical processes - second harmonic generation and expression for SHG efficiency - third order non-linear optical processes - third harmonic generation - intensity dependent refractive index - two photon absorption.

Text Book:

1. Laser fundamentals, William T. Silfvast, CUP 2nd Edn. 2009, (Chapter 16)

Reference Books:

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

ELECTIVES

Course Code: 16P4PHYT16 **number of credits = 3**

INSTRUMENTATION AND COMMUNICATION ELECTRONICS **number of Hrs. / Week = 3**

Unit I

Transducers and Digital Instrumentation (20 Hrs)

Transducers: Classification of transducers - electrical transducer - resistive transducer - strain gauges- piezo-electric and magnetostrictive transducers - Hall effect transducers -thermistor inductive transducer - differential output transducers - pressure transducers - pressure cell - photoelectric transducers - photo voltaic cell – semiconductor photo diode – thermo electric transducers - mechanical transducers – ionization transducers – digital transducers - electro chemical transducers.

Recorders: Strip chart recorders - XY recorders - digital XY plotters – magnetic recorders -digital data recording - Storage oscilloscope – Digital storage oscilloscope.

Unit II

Measurement of Basic Parameters (18 Hrs)

Transistor Voltmeter - amplified DC meter - chopper type DC amplifier voltmeter - milli voltmeter using operational amplifier - differential voltmeter - A.C voltmeters using rectifiers - true RMS responding voltmeter – Ohm meter – electronic multimeter – commercial multimeter – CRO (Basic ideas) – output power meters - stroboscope – phase meter – vector impedance meter – Q meter – transistor testers

Digital Instrumentation: - digital voltmeter – RAMP - voltage to time conversion - voltage to frequency conversion - frequency to voltage conversion - digital millimeter - digital frequency meter - time and Frequency measurement- Digital counters and timers - digital phase meter – tachometer- pH meter.

Unit III

Introduction to Communication (18 Hrs)

Bandwidth requirements – SSB technique – radio wave propagation – Ionosphere – Ionosphere variations – Space waves – Extra-terrestrial communication - Transmission lines – Basic principles – Characteristic impedance – Losses – Standing waves – Quarter and half wavelength lines. Television fundamentals – Monochrome transmission – Scanning – Composite TV video wave form – Monochrome reception – Deflection circuits – Colour Television. Basic ideas of high definition TV – LCD & LED TV

Text Books:

1. Electronic Instrumentation, H.S. Kalsi, TMH (1995)
2. Transducers and instrumentation, D.V.S. Murty, PHI (1995)
3. Monochrome and Colour Television R.R. Gulati, New Age India
4. Electronic communication systems, George Kennedy, TMH

Reference Books:

1. Modern electronic Instrumentation and Measurement Techniques, A.D. Helfric & W.D. Cooper,PHI, (1997)
2. Instrumentation-Devices and Systems 2nd Edn. C.S. Rangan, G.R. Sarma, V.S.V. Mani, TMH, (1998)
3. Electronic Measurements and Instrumentation, M.B. Olive & J.M. Cage, MGH, (1975)
4. Digital Instrumentation, A.J. Bouwens,TMH, (1998)
5. Elements of Electronic Instrumentation, J. Jha, M. Puri, K.R. Sukesh, & M.Kovar. Narosa, (1996)
6. Instrumentation Measurement and Analysis, B.C. Nakra & K.K. Chaudhry, TMH, (1998)
7. Op-amps and Linear Integrated Circuits, R.A. Gaykward, PHI, (1989)
8. Electronic fundamentals and Applications, John D. Ryder, PHI.
9. Electric and electronic measurements and instrumentation 10th Edn. A.K. Sawhney, Dhanpath Rai & Company.

ADVANCED ELECTRONICS PRACTICALS **16P4PHYP04**

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

[B] Communication Electronics

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

[C] Electronic Instrumentation

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

[D] Optoelectronics

19. Characteristic of a photo diode - Determination of the relevant parameters.

20. Beam Profile of laser, spot size and divergence.

21. Temperature co-efficient of resistance of copper.

22. Data transmission and reception through optical fiber link.