ST.PHILOMENA'S COLLEGE (AUTONOMOUS), MYSURU

(AFFILIATED TO UNIVERSITY OF MYSORE)

REACCREDITED BY NAAC WITH A GRADE

COURSE – M.Sc.

Two-year four semesters Choice Based Credit System (CBCS) and Continuous Assessment & Grading Pattern (CAGP) Post Graduate Programme under Autonomous Structure

Academic year 2018-19onwards

PG DEPARTMENT OF PHYSICS

PG DEPARTMENT OF PHYSICS
ST.PHILOMENAS COLLEGE (Autonomous), MYSURU
Master of Science in Physics

Course Preamble

The course provides firm foundation in various tools developed and used for understanding different natural phenomena. The M.Sc. programme lays emphasis on the courses that constitute core components, while providing students with a spectrum of optional papers covering most areas of physics. The students are also permitted to register for any one of the interdisciplinary elective papers, namely, Numerical methods, Material Science and Biophysics. In these papers, the students will learn to apply the tools of Physics in these interdisciplines of science. The department offers two Specializations, Condensed Matter Physics and Nuclear Physics, so that, those who wish to pursue higher studies in these domains are thereby well equipped to choose their branch of study. The programme also gives adequate skills in understanding the basic and advanced physics experiments.

PG DEPARTMENT OF PHYSICS
ST.PHILOMENAS COLLEGE (Autonomous), MYSURU
Master of Science in Physics

VISION AND MISSION OF THE COLLEGE

VISION:

The college is guided by the visionary zeal of providing value- based education to everyone irrespective of religion, caste, creed or sex by which the character is formed, intellect is explained and one can stand on his/her feet.

MISSION:

To transform young men and women who come to learn not from books, but also from life and to share the experience of working and playing together, which inculcates life skills to become good citizens with integrity and discipline.

About the Department

The PG Department of Physics was established in the year 2014. The vision of the Department is to empower the students with scientific temper, logical reasoning and analytical power towards overall development in the modern society.

VISION AND MISSION OF THE DEPARTMENT

VISION:

The department strives to empower the students with scientific temper, logical reasoning and analytical power towards overall development in the modern society.

MISSION:

1. Promoting the knowledge of Physics among students of the college and among the general public.

2. Developing an aptitude for science and moulding generations that build nations through scientific research and experiments.

PEO No.	Programme Educational Objectives (PEOs)
PEO-1	To kindle and foster strong interest and impart quality education in physics.
PEO-2	To develop a strong hold in the subject to be effective and efficient physicist to impart knowledge to the future generations.
PEO-3	To develop the skill to identify, execute, analyze and interpret the results of an extended experimental or theoretical Physics based problems in a research environment.
PEO-4	To facilitate professional development through continues learning with higher education and scientific research.

Mapping of Mission of the department with Programme Educational Objectives

Mission	Programme Educational Objectives (PEOs)			
	PEOs-1	PEOs-2	PEOs-3	PEOs-4
M1	✓	✓		
M2			✓	✓

Programme Outcomes (Pos)

POs describe what students are expected to know or be able to do by the time of graduation from the programme.

PO No.	Upon completion of the Programme the student will be able to:
PO-1	understand physical problems and obtain admissible mathematical and physical solutions by applying laws/ principles of physics.
PO-2	set up, conduct and interpret the data of basic and advanced experiments in physics.
PO-3	enhance and adopt new skills through seminar, internship and dissertation to be efficient in teaching and research.
PO-4	appreciate the need and involve in team/self-reliant lifelong learning in the context of their chosen disciplines.
PO-5	fare well at any degree of competitive examinations.

Programme Specific Outcomes PSOs

PSO No.	Upon completion of the Programme the student will :
PSO-1	Elucidate principles of physics in understanding various natural phenomena.
PSO-2	Be able to particularly have fundamental and advanced knowledge in core concepts along with their choice of specialization.
PSO-3	Design, execute, analyze and interpret basic and advanced experiments in physics.
PSO-4	Develop a strong hold in the subject to be effective and efficient teachers at school and college level
PSO-5	Be able to engage in research motives a ethically and produce results.

Mapping of Programme Educational Objectives with Program Outcomes and Programme Specific outcomes

	Program Outcomes					Program Specific Outcomes				
Programme Educational Objectives	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PSO-1**	**PSO-2**	**PSO-3**	**PSO-4**	**PSO-5**
PEOs-1				✓		✓				
PEOs-2	✓					✓	✓			
PEOs-3		✓	✓				✓	✓		
PEOs-4			✓	✓	✓				✓	✓

ST.PHILOMENA'S COLLEGE (Autonomous) MYSORE

Master of Science in Physics

The course will be started under the existing regulations governing two year- four semesters Choice Based Credit System (CBCS) and Continuous Assessment Grading Pattern (CAGP) Master's Degree Programmes under Autonomous Structure.

Guidelines/Regulations

1. Eligibility for Admission

Candidates shall have studied any branch of basic sciences with Physics as one of the major/optional/subsidiary subjects securing 45% marks (40% in case of SC/ST candidates) in the aggregate marks in Physics of all the semesters at the undergraduate level. The qualification and the percentage of marks for admission shall be as per the guidelines issued by the University of Mysore from time to time.

Note: -In case of candidates who have taken more than three years to complete their Bachelors Degree, the percentage of mark is arrived as per the guidelines issued by University of Mysore from time to time.

2. Duration of the Programme

The duration of Programme shall extend over 4 semesters (two academic years) of 20 weeks each including instructions and examinations.

3. Maximum Period for Completion of the Programme

The candidates shall complete the programme within 4 years from the date of admission. The term completing the programmes means passing all the prescribed examinations of the programme to become eligible for the degree. No candidate shall be permitted to appear for the examinations after the prescribed period for completing the programme. Whenever a candidate opts for blank semesters/ dropped papers, he/she have to study the prevailing papers offered by the Department when he /she continues his /her studies.

4. Medium of Instruction

The medium of instruction shall be English.

5. Hours of Instruction per Week

There shall be 24-30 hours of instructions per week in subjects without practical/field-work and 28-34 hours of instructions per week in subjects with practical/field-work. These hours may be distributed for lectures, seminars, tutorials, practicals, project-work and other modes of instruction which individual courses may demand.

6. Attendance

Each paper (theory/practical) shall be treated as an independent unit for the purpose of attendance. A student shall attend a minimum of 75% of the total instruction hours in a paper (theory/practical) including tutorials and seminars in each semester. There shall no provision for condonation of shortage of attendance and a student who fails to secure 75% attendance in a paper shall be required to repeat that semester with the payment of semester fees.

7. Guidelines to Implement CBCS & CAGP Master's Degree Programme

Course: Every paper offered will have three components associated with the teaching-learning process, namely

(a) **L -** Lecture (b) **T -**Tutorial (c) **P -** Practical

Where

L -Stands for Lecture session.

T - Stands for Tutorial session consisting participatory discussion/self-study/desk work/ brief seminar presentations by students and such other novel methods that make a student to absorb and assimilate more effectively the contents delivered in the Lecture classes.

P -Stands for Practical session and it consists of Hands on experience / Laboratory Experiments/Field Studies/Case studies that equip students to acquire the much required skill component.

In terms of credits, every one hour session of L amounts to one credit per semester and a minimum of two hour session of T or P amounts to one credit per semester, over a period of one semester of 16 weeks for teaching – learning process. The total duration of a semester is 20 weeks inclusive of semester end examination.

A paper shall have either one or two or all the three components. That means a paper may have only lecture component, or only practical component or combination of any two or all the three components.

The total credit earned by a student at the end of the semester upon successfully completing the course is equal to L + T + P of each paper.

Different papers of study are labelled and defined as follows:

Hard Core Paper

A paper which should compulsorily be studied by a candidate as a core requirement is termed as a **Hard Core Paper**.

Soft Core Paper/Elective Paper

If there is a choice or an option for the candidate to choose a paper from a pool of papers from the main discipline subject of study or from a sister/related discipline / subject which supports the main discipline/ subject is termed as a **Soft Core Paper**.

Generally a paper which can be chosen from a pool of papers and which may be very specific or specialized or advanced or supportive to the discipline / subject of study or which provides an extended scope or which enables an exposure to some other discipline / subject / domain or nurtures the candidate's proficiency / skill is called an Elective Paper.

Elective papers may be offered by the main discipline / subject of study or by sister / related discipline / subject of study. ***A Soft Core paper may also be considered as an elective.***

Open Elective

An elective paper chosen generally from an unrelated discipline / subject, with an intention to seek exposure is called an **open elective. A core paper offered in a discipline / subject may be treated as an elective by other discipline / subject and vice versa**.

Project work / Dissertation work

It is a special paper involving application of knowledge in solving / analyzing / exploring a real life situation / difficult problem.

Minor Project Work

A project work up to 4 credits is called Minor Project work.

Major Project Work

A project work of 6 to 8 credits is called Major Project Work.

Dissertation Work

A project work can be of 10 – 12 credits. A Project /Dissertation work may be a hard core or a soft core as decided by the BOS concerned.

8. Scheme of Instruction

8.1 A candidate has to earn a minimum of ***76 credits***, for successful completion of a Master's Degree with a distribution of credits for different papers as given in the following table.

Paper Type	Credits
Hard Core	Minimum of 42, Maximum of 52
Soft Core	Minimum of 16
Open Elective	Minimum of 08

8.2 A candidate can enroll for a maximum of 24 credits per semester.

8.3 Only such candidates who register for a minimum of 18 credits per semester and complete successfully 76 credits in 4 successive semesters shall be considered for declaration of ranks, medals and are eligible to apply for student fellowship, scholarship, free ships and hostel facilities.

9. Continuous Assessment, Earning of Credits and Award of Grades

The evaluation of the candidate shall be based on continuous assessment. The structure for evaluation is as follows:

9.1 Assessment and evaluation processes happen in a continuous mode. However, for reporting purposes, a semester is divided into 3 distinct components identified as C_1, C_2, and C_3

9.2 The performance of a candidate in a paper will be assessed for a maximum of 100 marks as explained below.

a) The first component (C_1) of assessment is for 15 marks. This will be based on test, assignment, seminar and attendance (Class Participation).During the first half of the semester, the first 50% of the syllabus will be completed. This shall be consolidated during the 8th week of the semester. Beyond 8th week, making changes in C_1 is not permitted. The marks for the class participation - 91-100 % -05 marks, 81-90% - 04 marks and 75-80% -03 marks.

b) The second component (C_2) of assessment is for 15 marks. This will be based on test, assignment, seminar and attendance (Class Participation). The continuous assessment and scores of second half of the semester will be consolidated during the 16th week of the semester. During the second half of the semester, the remaining units in the paper will be completed. The marks for the class participation- 91-100 % -05 marks, 81-90% 04 marks and 75-80% -03 marks

c) The outline for continuous assessment activities for Component – I (C_1) and Component – II (C_2) will be proposed by the teacher(s) concerned before the commencement of the semester and will be discussed and decided in the respective Departmental Council. The students should be informed about the modalities well in advance. The evaluated papers / assignments during component - I (C_1) and component - II (C_2) of assessment are immediately returned to the candidates after obtaining acknowledgement in the register maintained by the concerned teacher for this purpose.

d) During the 18th – 20th week of the semester, a semester end examination of 2 hours duration shall be conducted for each paper. This forms the third/final component of assessment (C_3) and the maximum marks for the final component will be 50.

10. Setting Question Papers and Evaluation of Answer Scripts.

a) Question papers in three sets shall be set one by the internal and two by the external examiners. While selecting the examiners the University Guidelines are to be followed. Whenever there are no sufficient internal examiners, the Chairman of Board of Examination [BOE] shall get the question papers set by external examiners.

b) The Board of Examiners shall scrutinize and approve the question papers and scheme of valuation.

c) There shall be single valuation for all theory papers by **external examiners**. A detailed scheme of valuation to be prepared by the department and to be provided to the external examiner along with the answer scripts

d) The examination for Practical Work / Field Work / Project Work will be conducted jointly by internal and external examiners. However, the BOE on its discretion can also permit two internal examiners from the College.

e) If a paper is full of (L = 0): T: (P=0) type, then the examination for C_3 component will be as decided by the BOS concerned.

f) The details of continuous assessment are summarized in the following Table

Component	Syllabus in a paper	Weightage	Period of continuous assessment
C_1	First 50% of the Syllabus	15%	First half of the semester To be consolidated by 8^{th} week
C_2	Remaining 50% of the Syllabus	15%	Second half of the semester To be consolidated by 16^{th} week
C_3	Semester-end examination (all units of the paper)	70%	To be completed during 18^{th} – 20^{th} Week
Final grades to be announced latest by 24^{th} week			

g) A candidate's performance from all 3 components will be in terms of scores, and the sum of all three scores will be for a maximum of 100 marks (15 + 15 + 70).

h) **Finally, awarding the grades should be completed latest by 24^{th} week of the Semester.**

11. Minor / Major Project Evaluation

Right from the initial stage of defining the problem, the candidate has to submit the progress reports periodically and also present his / her progress in the form of seminars in addition to the regular discussion with the guide. Components of evaluation are as follows:

Component – I (C_1): Periodic Progress and Progress Reports (15)
Component – II (C_2): Results of Work and Draft Report (15)
Component – III (C_3): Final Viva Voce and evaluation (70). The report evaluation is for 40 and the Viva –voce examination is for 30.

12. In case a candidate secures less than 30% in C_1 and C_2 put together in a paper, the candidate is said to have **DROPPED** that paper, and such a candidate is not allowed to appear for C_3 in that paper.

In case a candidate's class attendance in a paper is less that 75% or as stipulated by the College, the candidate is said to have **DROPPED** that paper, and such a candidate is not allowed to appear for C_3 in that paper.

Teachers offering the papers will place the above details in the P G Department Council meeting during the last week of the semester, before the commencement of C_3 and subsequently a notification pertaining to the above will be brought out by the Principal before the commencement of C_3 examination. A copy of this notification shall also be sent to the office of the Controller of Examinations.

12.1 In case a candidate secures less than 30% in C_3 he/she may choose **DROP/MAKEUP** option.

In case a candidate secures more than or equal to 30% in C_3 but his/her grade (G) = 4, as per section 12.5 below, then he/she may be declared to have been conditionally successful in that paper, provided that such a benefit of conditional clearance based on G = 4 shall not be availed for a maximum of **8credits** for the entire programme of Master's Degree of two years.

A candidate exercising his/her option to MAKEUP examination shall be declared passes if he/she secures more than or equal to 30% in C_3 provided he/she fulfils the conditions mentioned in the Para 12.1 & 12.5. To a candidate who does not pass in MAKE UP examination, no separate MAKEUP examination shall be conducted. Such a candidate has to appear for the examination as and when the C_3 component examination is conducted for Odd & Even semester of that academic year along with the regular candidates.

12.2 A candidate has to re-register for the DROPPED paper when the paper is offered again by the department if it is a hard core paper. The candidate may choose the same or an alternate core/elective in case the dropped paper is soft core/ elective paper. A candidate who is said to have DROPPED project work has to re-register for the same subsequently within the stipulated period. **The details of any dropped paper will not appear in the grade card.**

12.3 The tentative / provisional grade card will be issued by the Registrar (Evaluation) at the end of every semester indicating the papers completed successfully. This statement will not contain the list of DROPPED papers.

12.4 Upon successful completion of Master's degree a final grade card consisting of grades of all papers successfully completed by the candidate will be issued by the Registrar (Evaluation).

12.5 The Grade (G) and the Grade Point (GP) earned by the candidate in the subject will be as given below.

P	G	GP = V x G
90 – 100	10	V x 10
80 – 89.99	9	V x 9
70 – 79.99	8	V x 8
60 – 69.99	7	V x 7
50 – 59.99	6	V x 6
40 – 49.99	5	V x 5
30 – 39.99	4	V x 4
00 – 29.99	0	V x 0

Here, P is the percentage of marks $P = [(C_1+C_2) + C_3]$ secured by a candidate in a paper which is rounded to nearest integer. V is the credit value of paper. G is the Grade and GP is the Grade Point.

12.6 A candidate can withdraw any paper within ten days from the date of notification of final results of that semester. Whenever a candidate withdraws a paper, he/she has to register for the same paper in case it is hard core paper, the same paper or an alternate paper if it is soft core/open elective.

A DROPPED paper is automatically considered as a paper withdrawn.

12.7 The Semester Grade Point Average (SGPA) of a candidate after successful completion the required number of credits (76) is given by

$$\textbf{SGPA} = \frac{\sum GP}{\text{Totalnumberofcredits}}$$

12.8 The Final Semester Grade Point Average (SGPA) of a candidate after successful completion the required number of credits (76) is given by

$$\textbf{CGPA} = \frac{\sum \text{GPofallthefourSemesters}}{\sum \text{CreditsofalltheSemesters}}$$

13. Classification of results

The Final Cumulative Grade Point (FGP) to be awarded to the student is based on CGPA secured by the candidate and is given as follows:

CGPA	FGP	
	Numerical Index	Qualitative Index
4< = CGPA < 5	5	SECOND CLASS
5< = CGPA < 6	6	
6< = CGPA < 7	7	FIRST CLASS
7< = CGPA < 8	8	
8< = CGPA < 9	9	DISTINCTION
9< = CGPA < 10	10	

Overall percentage = 10 x CGPA or is said to be 50% in case CGPA < 5

PG DEPARTMENT OF PHYSICS
ST. PHILOMENA'S COLLEGE (AUTONOMOUS), MYSORE 570015
A COLLEGE OF EXCELLENCE (UGC)
M.Sc. PHYSICS SYLLABUS: 2016 - 17 ONWARDS
DURATION OF THE COURSE –TWO YEARS – FOUR SEMESTER
Specializations: i) Condensed Matter Physics and ii) Nuclear Physics
Scheme of Teaching
(L: Lecture, T: Tutorial, P: Practical)

Sl. No.	Code	Subject		Type HC/SC/OE	Credit Pattern L:T:P	Credits
FIRST SEMESTER						
1	**A0210**	Classical Mechanics		HC	3:0:0	3
2	**A0220**	Mathematical Methods of Physics		HC	3:0:0	3
3	**A0230**	Spectroscopy and Electronics		HC	3:0:0	3
4	**A0240**	Classical Electrodynamics and Optics		HC	3:0:0	3
5	**AP210**	Electronics Lab*		HC	0:0:4	4
6	**AP240**	Optics Lab*		HC	0:0:4	4
Students are permitted to register for any one of the following soft core papers						
7	**AP220**	Computer Lab A		SC	0:0:2	2
8	**AP230**	Computer Lab B		SC	0:0:2	2
Total Credits : 18 [HC: 16, SC: 2] *** Students can opt either Electronics/Optics Lab.**						
SECOND SEMESTER						
1	**B0210**	Theory of Relativity		HC	3:0:0	3
2	**B0220**	Quantum Mechanics 1		HC	3:0:0	3
3	**B0230**	Thermodynamics and Statistical Mechanics		HC	3:0:0	3
4	**BP210**	General Physics Lab		HC	0:0:2	2
5	**BP220**	Optics Lab^^		HC	0:0:4	4
6	**BP230**	Electronics Lab**		HC	0:0:4	4
Students are permitted to register for any one of the following soft core interdisciplinary papers						
7	**B0310**	Liquid Crystals		SC	3:0:0	3
8	**B0510**	Biophysics (Biochemistry)		SC	3:0:0	3
9	**B0520**	Materials Science (Chemistry)		SC	3:0:0	3
10		**Open Elective offered by other PG Departments**		OE	4:0:0	4
Total Credits : 22 [HC: 15, SC: 3, OE: 4] **** For those students who have completed Optics lab.** **^^ For those students who have completed Electronics lab.**						
THIRD SEMESTER						
1	**C0210**	Condensed Matter Physics		HC	3:0:0	3
2	**C0220**	Nuclear and Particle Physics		HC	3:0:0	3
3	**CP210**	Condensed Matter Physics Lab*		HC	0:0:4	4
4	**CP220**	Nuclear Physics Lab*		HC	0:0:4	4
Students are permitted to register for any one of the following groups						
5	**C0310**	Group-1	Condensed Matter Physics 1	SC	3:0:0	3
6	**CP310**		Condensed Matter Physics Lab 1	SC	0:0:2	2

7	**C0320**	Group-2	Nuclear Physics 1	SC	3:0:0	3
8	**CP320**		Nuclear Physics Lab 1	SC	0:0:2	2
9		**Open Elective offered by other PG Departments**		OE	4:0:0	4
Total Credits : 19 [HC: 10, SC: 5, OE: 4]						
* **Students can opt either Condensed Matter Physics Lab./Nuclear Physics Lab.**						

FOURTH SEMESTER						
Sl. No.	Code	Subject		Type HC/SC/OE	Credit Pattern L:T:P	Credits
1	**D0210**	Quantum Mechanics 2		HC	3:0:0	3
2	**DP220**	Condensed Matter Physics Lab**		HC	0:0:4	4
3	**DP210**	Nuclear Physics Lab^^		HC	0:0:4	4
Students are permitted to register for any one of the following elective papers						
4	**DP310**	Minor Project Work		SC	4:0:0	4
5	**D0310**	Accelerator Physics		SC	3:0:0	3
6	**D0320**	Space and Astrophysics		SC	4:0:0	4
7	**D0330**	Angular Momentum and Quantum Field Theory		SC	3:0:0	3
Students are permitted to register for any one of the following groups						
8	**D0340**	Group-1	Condensed Matter Physics 2	SC	3:0:0	3
9	**D0350**		Condensed Matter Physics 3	SC	3:0:0	3
10	**DP320**		Condensed Matter Physics Lab 2	SC	0:0:2	2
11	**D0360**	Group-2	Nuclear Physics 2	SC	3:0:0	3
12	**D0370**		Nuclear Physics 3	SC	3:0:0	3
13	**DP330**		Nuclear Physics Lab 2	SC	0:0:2	2
Total Credits : 19(18*) [HC: 7(6*), SC: 12]						
Total Credits earned during the whole course: 78(77*) [HC: 48, SC: 22(21*), OE: 8] *If student has opted for Accelerator Physics or Liquid Crystals instead of Minor Project Work. ** **For those students who have completed Nuclear Physics Lab.** ^^ **For those students who have completed Condensed Matter Physics Lab.**						

Open Elective papers offered for post graduate students of other departments

Sl. No.	Code	Subject	Type HC/SC/OE	Credit Pattern L:T:P	Credits
SECOND SEMESTER					
1.	**B8140**	Nanoscience and Nanotechnology	OE	4:0:0	4
THIRD SEMESTER					
2.	**C9150**	Environmental Physics	OE	4:0:0	4

FIRST YEAR - SEMESTER – I

<table>
<tr><td>Course Title</td><td colspan="9">Classical Mechanics</td></tr>
<tr><td>Course Type</td><td colspan="2">Hard Core- Theory</td><td>Total Hours</td><td>48</td><td colspan="2">Hours/Week</td><td>03</td><td>Credits</td><td>03</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">A0210</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="4">C1+C2 = 15+15</td><td>30 Marks</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td colspan="2">C3</td><td>Duration</td><td>03Hrs</td><td>70 Marks</td></tr>
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COURSE OBJECTIVES (Cos)

CO No.	On completion of the course the student will be able to:
CO-1	learn and understand Lagrangian and Hamiltonian formulations and apply to solve problems in mechanics.
CO-2	understand canonical transformations and evaluate Poisson brackets.
CO-3	acquire knowledge to derive Euler's equations and to apply them for rigid body dynamics.
CO-4	understand theory of small oscillations.

Mapping of CLOs with PSOs &CDLs

CLOs No.	**Course Learning Outcomes (CLOs)** **On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	solve problems with symbolic (rather than numeric) parameters.	PSO-1	Apply
CLO-2	use Lagrangian and Hamiltonian methods to solve mechanics problems.	PSO-2	Apply
CLO-3	analyze the dynamics of rigid body using Lagrangian approach.	PSO-2	Analyze

Course Outline

UNIT-1 Mechanics of system of particles-1 — 16hrs

1.1 Conservation of momenta and energy[Ref.1]

1.1.1 Conservation of linear and angular momenta in the absence of net external forces and torques using centre of mass

1.1.2 The energy equation and the total potential energy of a system of particles using scalar potential

1.2 The Lagrangian method[Ref.1]

1.2.1 Constraints and their classifications, generalized coordinates, virtual displacement

1.2.2 D'Alembert's principle and Lagrangian equations of the second kind, examples of (i) single particle in Cartesian, spherical, polar and cylindrical polar coordinate systems, (ii) Atwood's machine, (iii) bead sliding on a rotating wire in a force-free space, and (iv) simple pendulum (v) simple electrical circuits

1.2.3 Velocity dependent potential: the Lagrangian for a charged particle in an external electromagnetic field, derivation of Lagrangian equations from Hamilton's principle

1.3 Noether's theorem statement and proof

1.4 **Motion of a particle in a central force field:** Binet equation for central orbit (Lagrangian method), Kepler problem and inverse Kepler problem, Virial theorem[Ref.1]

Key words: Degrees of freedom, conservation

UNIT-2 Mechanics of system of particles-2 — 16hrs

2.1 Hamilton's equations[Ref.1,3]

2.1.1 Generalized momenta, Hamilton's equations, examples of (i) simple harmonic oscillator, (ii) simple pendulum, (iii) compound pendulum, (iv) motion of a particle in a central force field, (v) charged particle moving in an electromagnetic field, and (vi) a free particle in different coordinates

2.1.2 Cyclic coordinates, physical significance of the Hamiltonian function, derivation of Hamilton's equations from variational principle

2.2 Canonical transformations[Ref.1,2,4]

2.2.1 Definition, generating functions (four basic types), examples of canonical transformations

2.2.2 Harmonic oscillator as an example to canonical transformation, infinitesimal contact transformation

2.2.3 Poisson brackets, properties of Poisson brackets, angular momentum and Poisson bracket relations, equations of motion in the Poisson bracket notation

2.2.4 The Hamilton-Jacobi equation, example of the harmonic oscillator treated by the Hamilton-Jacobi method

Key words: Least action, Hamilton Jacobi equation

UNIT-3 Rigid body dynamics and small oscillations **16hrs**

3.1 Mechanics of rigid bodies [Ref.1]

3.1.1 Degrees of freedom of a free rigid body

3.1.2 Angular momentum and kinetic energy of a rigid body

3.1.3 Moment of inertia tensor, principal moments of inertia, products of inertia

3.1.4 Euler equations of motion for a rigid body

3.1.5 Torque free motion of a rigid body, precession of earth's axis of rotation

3.1.6 Euler angles, angular velocity of a rigid body

3.2 Small oscillations of a mechanical system[Ref.1]

3.2.1 Introduction, types of equilibria, quadratic forms of kinetic and potential energies of a system in equilibrium

3.2.2 General theory of small oscillations, secular equation and Eigen value equation

3.2.3 Small oscillations in normal coordinates and normal modes, examples of two coupled oscillators, vibrations of a linear tri-atomic molecule

Key words: Rigid body, small oscillations

References

1 Upadhyaya J.C., Classical Mechanics, Himalaya Publishing House, Mumbai. 2006.

2 Goldstein H., Poole C. and Safko J., Classical Mechanics, 3rd Edn., Pearson Education, New Delhi. 2002.

3 SrinivasaRao K.N., Classical Mechanics, Universities Press, Hyderabad, 2003.

4 Takwale R.G. and Puranik S., Introduction to Classical Mechanics, Tata McGraw, New Delhi, 1991.

5 B.A Kagali and T. Shivalingaswamy, Classical Mechanics, Himalaya Publishing House, Mumbai, 2018.

6 John R. Taylor, Classical Mechanics, University Science Books, 2004.

FIRST YEAR - SEMESTER – I

Course Title	Mathematical Methods of Physics								
Course Type	Hard Core- Theory		Total Hours	48	Hours/Week	03		Credits	03
Course Code	**A0220**	Evaluation	Internal	C1+C2 = 15+15				30 Marks	100
			External	C3	Duration		03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	learn advanced mathematical concepts used in physics.
CO-2	understand the methods and solutions of special functions of mathematical physics.
CO-3	use Fourier series, Fourier and Laplace transforms to solve physical problems.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	be familiar with the main mathematical methods used in physics.	PSO-1	Understand
CLO-2	explain the origin of Bessel functions, Legendre polynomial, Hermite polynomial and Laguerre polynomials and use their properties in relevant problems in physics.	PSO-1 PSO-3 PSO-5	Understand
CLO-3	learn to apply Fourier series, Fourier and Laplace transforms, their inverse transforms in relevant problems in physics.	PSO-1 PSO-3 PSO-5	Apply

Course Outline

UNIT-1 Differential equations — 16hrs

1.1 Regular and irregular singular points of a second order ordinary differential equations, Fuch theorem, superposition principle

1.2 **Special functions** [Ref.1-3]

1.2.1 **Bessel functions:** Frobenius Series solution, generating functions, recurrence relations, orthogonality properties, Bessel function of the first kind, Neumann functions, spherical Bessel functions(definition only)

1.2.2 **Legendre functions and polynomials:** Power Series solution, generating functions, orthogonality properties, Rodrigue’s representation, Spherical harmonics. Associated functions, separation of variables – Helmholtz equation in Cartesian, cylindrical and spherical polar coordinates

1.2.3 **Hermite functions and polynomials:** Power Series solution, generating functions, recurrence relations, orthogonality properties, Rodrigue’s representation

1.2.4 **Laguerre functions and polynomials:** Power Series solution, generating functions, recurrence relations, orthogonality properties, Rodrigue’s representation

Key words: Special functions, Helmholtz equation, Power Series solution

UNIT-2 Fourier transforms — 16hrs

2.1 Introduction to Fourier series, Integral transforms

2.2 Development of the Fourier integral, Fourier transforms – inversion theorem, Fourier transform of derivatives, convolution theorem, momentum representation[Ref.1]

2.3 Fourier transform of Dirac delta function

2.4 **Integral equations**[Ref.1]

2.4.1 Types of linear integral equations – definitions
2.4.2 Transformation of a differential equation into an integral equation
2.4.3 Abel's equation, Neumann series, separable kernels

Key words: Fourier transforms, integral transforms

UNIT-3 Tensor analysis **16hrs**

3.1 Tensors of rank r as a r-linear form in base vectors, transformation rules for base vectors and tensor components, invariance of tensors under transformation of coordinates.

3.2 Sum, difference and outer products of tensors, contraction, symmetric and antisymmetric tensors.

3.3 Curvilinear coordinates in the Euclidean 3-dimensional space, covariant and contravariant basis vectors, covariant and contravariant components of the metric tensor, raising and lowering of indices, differentials of base vector fields

3.4 Christoffel symbols, covariant differentiation, the contracted Christoffel symbols. Gradient, divergence, curl and Laplacian in arbitrary curvilinear coordinates. [Ref.3,5]

Key words: Tensors, Christoffel symbols

References

1 Arfken G.B. and Weber H.J., Mathematical Methods for Physicists, 4thEdn., Academic Press, New York (Prism Books, Bangalore, India), 1995.
2 Harper C., Introduction to Mathematical Physics, PHI Learning Pvt. Ltd., New Delhi, 1976.
3 Guptha B.D., Mathematical Physics, 4thEdn.,Vikas Publishing House Pvt. Ltd., Noida, 2011.
4 Harris E.G., Introduction to Modern Theoretical Physics, Vol. 1, John Wiley, New York, 1975.
5 Joshi A.W., Matrices and Tensors in Physics, New Age International Publishers, New Delhi, 1995.
6 Mary Boas, Mathematical Methods in Physical Sciences, 3rdEdn., Wiley, 2006.
7 Erwin Kreyszig, Advanced engineering Mathematics, 9thEdn., Wiley, 2011.

FIRST YEAR - SEMESTER – I

Course Title	**Spectroscopy and Electronics**								
Course Type	Hard Core- Theory		Total Hours	48	Hours/Week		03	Credits	03
Course Code	**A0230**	Evaluation	Internal	C1+C2 = 15+15				30 Marks	100
			External	C3	Duration		03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	learn theoretical aspects of modern atomic and molecular spectroscopic techniques and their applications in research field.
CO-2	acquire knowledge about analog and digital electronic devices.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**

CLO-1	explain the change in behaviour of atoms in external applied electric and magnetic field.	PSO-1 PSO-2	Understand
CLO-2	explain rotational, vibrational, electronic and Raman spectra of molecules.	PSO-1 PSO-2	Understand
CLO-3	describe electron spin and nuclear magnetic resonance spectroscopy and their applications.	PSO-1 PSO-2	Understand
CLO-4	design op-amp circuits.	PSO-1 PSO-2	Understand

Course Outline

UNIT-1 Atomic spectroscopy and molecular spectroscopy-1 **16hrs**

1.1 Atomic spectroscopy [Ref.1]

1.1.1 Spectroscopic terms and their notations. Spin-orbit interaction, quantum mechanical relativistic correction, Lamb shift

1.1.2 Zeeman effect, normal and anomalous Zeeman effect

1.1.3 Paschen-Back effect, Stark effect, weak field and strong field effects

1.1.4 Hyperfine structure of spectral lines - nuclear spin and hyperfine splitting, intensity ratio and determination of nuclear spin, breadth of spectral lines, natural breadth, Doppler effect and external effect

1.2 Molecular spectroscopy-1

1.2.1 **Microwave spectroscopy**-Introduction, classification of molecules
The rotational spectra of rigid diatomic rotator and spectra of non-rigid diatomic rotator, microwave spectrometer. [Ref.2]

1.2.2 **Infrared spectroscopy –**Introduction, Vibrational energy of diatomic molecule, anharmonic oscillator, the diatomic vibrating rotator, example of the CO molecule IR and FTIR spectrometers. [Ref.2]

Key words: Spin-orbit interaction, Zeeman effect, rotational and vibrational spectra

UNIT-2 Molecular spectroscopy-2 **16hrs**

2.1 Raman spectroscopy[Ref.2]

2.1.1 The quantum theory of Raman effect, pure rotational Raman spectra of linear molecules and symmetric top molecules

2.1.2 Vibrational Raman spectra, rotational fine structure, instrumentation technique in Raman spectroscopy

2.2 Electronic spectroscopy of molecules[Ref.2]

2.2.1 Electronic spectra of diatomic molecules, Vibrational coarse structure

2.2.2 The Frank-Condon principle, rotational fine structure of electronic-vibration transitions, fluorescence and phosphorescence, techniques and instrumentation

2.3 NMR spectroscopy[Ref.2]

2.3.1 Resonance condition, spin-lattice and spin-spin relaxation, chemical shift and coupling – example of ethyl alcohol

2.3.2 Continuous wave and FTNMR spectroscopy, note on CNMR and MRI

2.4 ESR spectroscopy[Ref.2]

2.4.1 Resonance condition, electron-nucleus and electron-electron coupling, double resonance, ESR spectrometer

Key words: Raman effect, NMR, ESR

UNIT-3 Electronics **16hrs**

3.1 Analog electronics

3.1.1 **Operational amplifiers**: Concepts of differential amplifier, block diagram and equivalent circuit of op-amp, op-amp parameters, open loop and closed loop

	configurations, virtual ground concept, inverting amplifier and non-inverting amplifier, applications - summing, scaling and averaging amplifiers
3.1.2	Voltage follower, voltage to current converter, current to voltage converter, integrator, differentiator, Schmitt trigger, phase shift oscillator, Wein bridge oscillator, first and second order low pass and high pass filters. IC555 timer as monostable and astable multivibrators[Ref.6]
3.2	**Digital electronics [**Ref.7]
3.2.1	Boolean laws and theorems, clocked flip flops - RS, JK, D and T flip flops
3.2.2	Decoders-BCD decoders, encoders Combinational logic circuits -half adders full adders and subtractors
3.2.3	Shift registers: series-in-series-out and parallel-in-parallel-out. asynchronous and synchronous counters and their applications (qualitative), memory cells and memory registers (qualitative)

Key words: Operational amplifiers, Boolean algebra,flip-flops, Registers

References

1 Rajkumar, Atomic and Molecular Spectra Laser, KedarNath Ram Nath, India, 2015.
2 Banwell C.N. and Mccash E.M., Fundamentals of Molecular Spectroscopy, 4th Edn., Tata McGraw-Hill, New Delhi, 1995.
3 Tralli N. and Pomilla P.R., Atomic Theory, Tata McGraw-Hill, New York, 1999.
4 RitaKakkar, Atomic and Molecular Spectroscopy, 1stEdn.CambridgeUniversity Press, Cambridge, 2015.
5 McHale J. L., Molecular Spectroscopy, Pearson Education, India, 2008.
6 Gaekwad R.A., Operational Amplifiers and Linear Integrated Circuits, Prentice-Hall of India, New Delhi, 1993.
7 Malvino A.P. and Leach D.P., Digital Principles and Applications, 4th Edn., Tata McGraw Hill,1988.

FIRST YEAR - SEMESTER – I

Course Title	**Classical Electrodynamics and Optics**							
Course Type	Hard Core- Theory		Total Hours	48	Hours/Week	03	Credits	03
Course Code	**A0240**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100
			External	C3	Duration	03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	understand basic theories of classical electrodynamics, Maxwells equations and their consequences to electromagnetism.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	have a deep understanding of the theoretical foundations of electromagnetic phenomena.	PSO-2 PSO-4	Understand

Course Outline

UNIT-1 Classical electrodynamics — 16hrs

1.1 Electric multipole moments[Ref.1,2]

1.1.1 The electric dipole and multipole moments of a system of charges

1.1.2 Multipole expansion of the scalar potential of an arbitrary charge distribution

1.2 Potential formulation[Ref.1,2]

1.2.1 Maxwell equations in terms of electromagnetic potentials

1.2.2 Gauge transformations, the Lorentz, Coulomb and radiation gauges

1.3 Fields of moving charges and radiation[Ref.1,2]

1.3.1 Retarded potentials, the Lienard-Wiechert potentials

1.3.2 Fields due to an arbitrarily moving point charge, the special case of a charge moving with constant velocity

1.4 Radiating systems[Ref.1,2]

1.4.1 Radiation from an oscillating dipole, power radiated by point charges, Larmor formula, Lienard's generalisation of Larmor formula, energy loss in bremsstrahlung and linear accelerators, radiation reaction, Abraham-Lorentz formula

Key words: Electric multipole, Maxwell's equations, radiating systems

UNIT-2 Electromagnetic theory — 16hrs

2.1 Electromagnetic waves

2.1.1 Monochromatic plane waves - velocity, phase and polarization

2.1.2 Propagation of plane electromagnetic waves in (i) conducting media and (ii) ionized gases. [Ref.3]

2.1.3 Reflection and refraction of electromagnetic waves - Fresnel formulae for parallel and perpendicular components, Brewster law. [Ref.4]

2.2 Propagation of light in an anisotropic medium[Ref.4]

2.2.1 Structure of a plane electromagnetic wave in an anisotropic medium, dielectric tensor

2.2.2 Fresnel's formulae for the light propagation in crystals, optical classification of crystals, light propagation in uniaxial and biaxial crystals

2.3 Interference[Ref.4]

2.3.1 General theory of interference of two monochromatic waves

2.3.2 Two-beam and multiple-beam interference with a plane-parallel plate

2.3.2 Fabry-Perot interferometer: etalon construction, resolving power, applications

2.4 Diffraction[Ref.4]

2.4.1 Fresnel-Kirchhoff diffraction formula

2.4.2 Conditions for Fraunhofer and Fresnel diffraction, Fraunhofer diffraction due to a circular aperture

Key words: EM waves, interference, diffraction

UNIT-3 Fourier, nonlinear and fiber optics — 16hrs

3.1 Fourier optics[Ref.6]

3.1.1 Spatial frequency filter–effect of a thin lens on an incident field distribution

3.1.2 Lens as a Fourier transforming element, application to phase contrast microscopy

3.2 Nonlinear optics[Ref.7]

3.2.1 Origin of nonlinearity, susceptibility tensor, phase matching, second harmonic generation

3.2.2 Optical rectification and phase matching, third harmonic generation, nonlinear optical materials

3.3 Fiber optics

3.3.1 Waveguides, TE and TM modes, TE waves in rectangular waveguide, TM waves in coaxial transmission line. [Ref.1]

3.3.2 Components of optical fiber communication system, optical fiber waveguides: construction, principle of light transmission, classification - step index, graded index, single and multi-mode, attenuation in fibers, couplers and connectors. [Ref.8]

Key words: Fourier optics, Nonlinear optics, wave guides, optical fibers

References

1 Griffiths D.J., Introduction to Electrodynamics, 5th Edn., Prentice-Hall of India, New Delhi, 2003
2 Laud B.B., Electromagnetics, Wiley Eastern Limited, India, 2000.
3 Gupta S.L., Kumar V., Singh S. P., Electrodynamics, PragatiPrakashan, Meerut, 2008.
4 Born M. and Wolf E., Principles of Optics, 6th Edn., Pergamon Press, Oxford, 1970.
5 Jackson J.D., Classical Electrodynamics, 2nd Edn. Wiley-Eastern Ltd, India, 1998.
6 Mateev A.N., Optics, Mir Publishers, Moscow, 1988.
7 Sautherland R. L., Handbook of Nonlinear Optics, 2nd Edn. CRC Press, USA, 2003.
8 Palais J. C., Fiber Optic Communication, Pearson, New Jersey, 2005.

FIRST YEAR - SEMESTER – I

Course Title	**Electronics Lab**							
Course Type	Hard Core- Practical		Total Hours	128	Hours/Week	08	Credits	03
Course Code	**AP210**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100
			External	C3	Duration	03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	design and conduct analog electronics experiments using opamp IC 741C.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs)** **On completion of the course the student will learn to:**	**PSOs Addressed**	**CLDs**
CLO-1	analyze and design circuits employing integrated-circuit operational amplifiers.	PSO-3 PSO-4	Analyze

Course Outline

Any eight of the following experiments:

1 Regulated power supply.
2 Op-amp characteristics.
3 Op-amp as inverting and non-inverting amplifier.
4 Op-amp as summing and difference amplifier.
5 Op-amp voltage follower.
6 Op-amp active filters: low pass and high pass (first order).
7 Op-amp active filters: low pass and high pass (second order).

8 Op-amp as integrator and differentiator.
9 Op-amp phase shift oscillator.
10 Op-amp Wein bridge oscillator.
11 Encoder and decoder.
12 Verification of Boolean laws.
13 Half adder and full adder, half subtractor and full subtractor.
14 RS and JK flip-flops.

FIRST YEAR - SEMESTER – I

Course Title	Optics Lab								
Course Type	Hard Core- Practical		Total Hours	128	Hours/Week	08	Credits	03	
Course Code	**AP240**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100	
			External	C3	Duration	03Hrs	70 Marks		

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	develop skills in use of advanced optical equipment's to study these phenomena and verify laws of optics.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs)** **On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	set up and operate advanced experiments in optics.	PSO-3 PSO-4	Apply
CLO-2	study and verify different optical phenomena.	PSO-3 PSO-4	Apply

Course Outline

Any eight of the following experiments:

1 Verification of the Brewster's law of polarization.
2 Verification of Fresnel laws of reflection from a plane dielectric surface.
3 Birefringence of mica using Babinet compensator.
4 Birefringence of mica by using the quarter-wave plate.
5 Experiments with Michelson interferometer.
6 Determination of the size of lycopodium spores by the method of diffraction haloes.
7 Determination of the wavelength of light by using the Fabry-Perot etalon.
8 Verification of Malus' law.
9 Experiments with source laser.
10 Study of elliptically polarized light.
11 Determination of the refractive index of air by Jamin interferometer.
12 Determination of Stokes vector of a partially polarized light beam.
13 Determination of thickness of mica sheet using Edser Butler Fringes.
14 Determination of wavelength of He-Ne laser by Michelson interferometer.
15 Diffraction of laser light by single slit and diffraction grating
a) determination of wavelength of laser,

b) determination of distance between two slits using interference of laser light through double slit.

FIRST YEAR - SEMESTER – I

<table>
<tr><td>Course Title</td><td colspan="8">Computer Lab A</td></tr>
<tr><td>Course Type</td><td colspan="2">Soft Core- Practical</td><td>Total Hours</td><td>64</td><td>Hours/Week</td><td>04</td><td>Credits</td><td>02</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">AP220</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30 Marks</td><td>100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>03Hrs</td><td>70 Marks</td><td></td></tr>
</table>

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	inculcate the skills in use of computers.
CO-2	familiar with the use of open source operating system LINUX.
CO-3	analyze errors and their propogation in experiments.
CO-4	use scientific text processing package LATEX, plotting package GNUPLOT.

<table>
<tr><td colspan="4">Mapping of CLOs with PSOs &CDLs</td></tr>
<tr><td>CLOs No.</td><td>Course Learning Outcomes (CLOs)
On completion of the course the student will learn to:</td><td>PSOs Addressed</td><td>CLDs</td></tr>
<tr><td>CLO-1</td><td>work on different tools provided on Linux platform.</td><td>PSO-3
PSO-4</td><td>Apply</td></tr>
<tr><td>CLO-2</td><td>scientific writing using LATEX package.</td><td>PSO-5</td><td>Understand</td></tr>
</table>

Introduction to Linux (O.S)

Basics of Linux operating system: Login procedure; creating, deleting directories; copy, delete, renaming files; absolute and relative paths; permissions-setting, changing-using text editor. **(4 sessions)**

Scientific text processing with LATEX: Typeset text using text effects, special symbols, lists, table, mathematics and including figures in documents **(6 sessions)**

Presentation using beamer **(4 sessions)**

Using the plotting program GNUPLOT: Plotting commands: to plot data from an experiment and applying least-squares fit to the data points, including a plot in a LATEX file **(2 sessions)**

FIRST YEAR - SEMESTER – I

<table>
<tr><td>Course Title</td><td colspan="8">Computer Lab B</td></tr>
<tr><td>Course Type</td><td colspan="2">Soft Core- Practical</td><td>Total Hours</td><td>64</td><td>Hours/Week</td><td>04</td><td>Credits</td><td>02</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">AP230</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30 Marks</td><td>100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>03Hrs</td><td>70 Marks</td><td></td></tr>
</table>

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	develop and execute a few C programs aimed at solving simple mathematical and basic physics problems.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to:**	**PSOs Addressed**	**CLDs**
CLO-1	generate and execute C programme for different problems using Linux.	PSO-4	Apply
CLO-2	solve programmes for special functions in Physics using C.	PSO-4 PSO-5	Apply

Experiments:

- Basic LINUX and gnuplot commands.
- Programming in C
  - **Part A**

    A minimum of six of the following programs:

    1. Check whether given number is odd or even.
    2. Check whether the input number is prime or not.
    3. Compute the Fibonacci sequence.
    4. Compute the roots of a quadratic equation.
    5. Addition of two m × n matrices.
    6. Matrix multiplication.
    7. Find the largest and smallest number in the input set.
    8. Generate Pascal's triangle.
    9. To find the sum and average of a data stored in a file.
    10. Linear least-squares fitting to data in a file.
  - **Part B**

    A minimum of four of the following programs:

    1. To find the trajectory of a projectile shot with an initial velocity at an angle. Also, find the maximum height travelled and distance travelled. Write the trajectory data to a file specified and plot using Gnuplot.
    2. The Legendre polynomials generator.
    3. The Bessel functions generator.
    4. Classical scattering.
    5. Eigen value problem of the 1D Schrodinger equation.
    6. Discrete and fast Fourier transforms.
    7. The Maxwell velocity distribution generator.
    8. Simulation of diffraction as Fourier transformation.

FIRST YEAR - SEMESTER – II

<table>
<tr><td>Course Title</td><td colspan="8">Theory of Relativity</td></tr>
<tr><td>Course Type</td><td colspan="2">Hard Core- Theory</td><td>Total Hours</td><td>48</td><td>Hours/Week</td><td>03</td><td>Credits</td><td>03</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">B0210</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="3">C1+C2 = 15+15</td><td>30 Marks</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td>03Hrs</td><td>70 Marks</td></tr>
</table>

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	understand basic concepts of special theory of relativity such as Minkowski space time continuum.
CO-2	extend their understanding of special theory of relativity by including the relativistic electrodynamics.
CO-3	understand theory of general relativity and its consequences.
CO-4	understand the theory of gravitational waves and detection.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	understand the paradoxes in special relativity.	PSO-1 PSO-2	Understand
CLO-2	understand the significance of the postulates of special and general relativity.	PSO-1 PSO-2	Understand
CLO-3	understand the invariance of Maxwell's field equations .	PSO-1 PSO-2	Understand
CLO-4	identify and experimentally detect gravitational waves.	PSO-3 PSO-4	Analyze

Course Outline

UNIT-1 Special theory of Relativity **16hrs**

1.1 Minkowski space time[Ref.1-3]

1.1.1 Real coordinates in Minkowski space time

1.1.2 Definition of 4-tensors, the Minkowski scalar product and the Minkowski metric

1.1.3 Orthogonality of 4-vectors, time like, null like and space like vectors and world-lines, the light-cone at an event.

1.2 Relativistic mechanics of a material particle[Ref.1-3]

1.2.1 The proper-time interval dτ along the world- line of a material particle

1.2.2 The instantaneous (inertial) rest-frame of a material particle and the components of 4-velocity, 4-acceleration, 4-momentum and 4-force vector in this frame, statement of second law of Newton in this frame.

1.2.3 Motion of a particle under the conservative 3-force field and the energy integral, the rest energy and the relativistic kinetic energy of a particle.

Key words: Special relativity, Minkowski space, 4-tensors

UNIT-2 General theory of Relativity **16hrs**

2.1 Einstein's equations[Ref.4]

2.1.1 Newtonian gravitational potential, inconsistencies of Newtonian gravitation with STR

2.1.2 The concepts of inertial and gravitational mass, the weak equivalence principle

2.1.3 Eötvös experiment, Einstein's elevator thought experiment

2.1.4 The Einstein equivalence principle, metrics, parallel transport, geodesics, curvature tensor and its properties

2.1.5 Gravitation as space time curvature, logical steps leading to Einstein's field equations of gravitation and its Newtonian limits.

2.2 Applications of general theory of relativity[Ref.4]

2.2.1 Schwarzschild's solution of Einstein's vacuum field equations

2.2.2 Motion of particles and light rays in the Schwarzschild field, explanation of the (i) perihelion advance of planet mercury, (ii) gravitational red shift, (iii) gravitational bending of light, and, (iv) gravitational waves, the Schwarzschild singularity and the Schwarzschild black hole (qualitative).

Key words: General relativity, Einsteins equations, space time curvature, Schwarzschilds solution

Unit 3 Relativistic electrodynamics and gravitational radiation 16hrs

3.1 Electrodynamics in covariant form[Ref.1-3]

3.1.1 The 4-potential A_i and the 4-current density J_i, the Maxwell field tensor F_{ij} and its dual

3.1.2 Maxwell's field equations in covariant form, the equation of continuity

3.1.3 The Lorentz 4-force on a charge, the guage invariance of F_{ij} in terms of the 4-potential.

3.2 Gravitational radiation [Ref. 5,6]

3.2.1 Introduction to gravitational waves

3.2.2 Linearized approximation : Plane waves

3.2.3 Radiation of gravitational waves

3.2.4 Cosmic sources of gravitational waves :i)coalescing binaries ii) explosive sources

3.2.5 Experimental detection of gravitational waves: i) bar detectors ii) LASER interferometer iii) LISA From space (qualitative)

Key words: Covariant formulations, Gravitational radiation, LISA

References

1 Landau L.D. and Lifshitz E.M., The Classical Theory of Fields, 4th Edn., Pergamon Press, Oxford, 1985.
2 Synge J.L., Relativity: The Special Theory, North-Holland Publishing Company, Amsterdam, 1972.
3 Rindler R., Relativity: Special, General and Cosmological, Oxford University Press, 2006.
4 Wald R.M., General Relativity, The University of Chicago Press, Chicago, 1984.
5 Jayant V. Narlikar, An Introduction to Relativity,2nd Edn., Cambridge University Press,2011
6 Schutz B.F., A First Course in General Relativity, Cambridge University Press, Cambridge, 1985.
7 Bhatia V.B., Textbook of Astronomy and Astrophysics with Elements of Cosmology, Narosa Publishing House, New Delhi, 2001.
8 Abhyankar K. D., Astrophysics – Stars and Galaxies, Universities Press, India, 2001.
9 B.A Kagali and T. Shivalingaswamy, Classical Mechanics, Himalaya Publishing House, Mumbai, 2018.

FIRST YEAR - SEMESTER – II

<table>
<tr><td>Course Title</td><td colspan="9">Quantum Mechanics - I</td></tr>
<tr><td>Course Type</td><td colspan="2">Hard Core- Theory</td><td>Total Hours</td><td>48</td><td colspan="2">Hours/Week</td><td>03</td><td>Credits</td><td>03</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">B0220</td><td rowspan="2">Evaluation</td><td>Internal</td><td colspan="4">C1+C2 = 15+15</td><td>30 Marks</td><td rowspan="2">100</td></tr>
<tr><td>External</td><td>C3</td><td>Duration</td><td colspan="2">03Hrs</td><td>70 Marks</td></tr>
</table>

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	familiar with the basic theoretical concepts and formalism of quantum mechanics.
CO-2	solve Eigenvalue problems for exactly solvable systems.
CO-3	understand time independent perturbation theory along with some of its applications.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	solve the Schrödinger equation for simple configurations.	PSO-2 PSO-4	Apply
CLO-2	solve perturbed systems using quantum mechanics.	PSO-2 PSO-4	Apply

Course Outline

UNIT-1 Mathematical aspects and formalism **16hrs**

1.1 Linear vector spaces
1.1.1 Definitions, linear dependence, linear independence
1.1.2 Bases, change of bases, inner product spaces
1.1.3 Dual spaces and Dirac notation
1.1.4 Matrix representation of linear operators. [Ref.2].
1.2 Formalism
1.2.1 Postulates of quantum mechanics: Hilbert space, observables
1.2.2 Eigen values and Eigen functions of a Hermitian operator, expectation values.
1.2.3 The canonical commutation relations, compatible and non-compatible observables, Generalized uncertainty relations. [Ref.1].
1.2.4 Wave functions in position and momentum space, momentum operator in position Eigen basis, position operator in momentum basis.
1.2.5 Quantum dynamics: Time evolution, The Schrödinger and Heisenberg picture**.** Interaction picture. Equations of motion.
1.3 The wave function, the Schrödinger equation, the statistical interpretation, probability, discrete and continuous variables, normalization, momentum, the uncertainty principle. [Ref.1]

Key words: Linear vector spaces, Formalism, Schrödinger equation

UNIT-2 The time-independent Schrödinger equation **16hrs**

2.1 Stationary states
2.2 Review of infinite square well
2.3 The harmonic oscillator - algebraic and analytical methods,
2.4 The free particle
2.5 Gaussian wave packet
2.6 The delta-function potential
2.7 The finite square well, potential barrier penetration
2.8 Quantum Mechanics in three dimensions[Ref.1]
2.8.1 Schrödinger equations in spherical polar co-ordinates, the hydrogen atom, angular momentum and spin. [Ref.1]
2.9 Identical particles: Two particle systems, atoms, solids. [Ref.1]

Key words: Stationary states, hydrogen atom

UNIT-3 The time independent perturbation theory **[16hrs]**

3.1 Non-degenerate perturbation theory, first and second order perturbation

3.2 Degenerate perturbation theory
3.3 Fine structure of hydrogen atom
3.4 Zeeman effect
3.5 The variational principle: theory-the ground state of helium, ionic state of diatomic hydrogen
3.6 The WKB approximation: The classical turning points, Bohr quantization formula tunnelling. [Ref.1]

Key words: Perturbations, approximations

References

1 Griffiths D.J., Introduction to Quantum Mechanics, 2ndEdn., Pearson, India, 2014.
2 Shankar R., Principles of Quantum Mechanics, 2ndEdn. Springer (India) Pvt. limited, 1994.
3 Thankappan V.K., Quantum Mechanics, 2ndEdn., New Age International (P) Limited Publishers, New Delhi, 2003.
4 Claude cohen-Tannoudji, Bernard Diu, Frank Laloe, Quantum Mechanics, Wiley, 2006.
5 SchiffL.I., Quantum mechanics, 3rdEdn., Tata McGraw-Hill, New Delhi, New Delhi 1968.
6 Sakkurai J. J., Modern Quantum Mechanics, 2ndEdn., Pearson, 2010.
7 Mathew P. M. and Venkateshan K., Quantum Mechanics, Tata McGraw-Hill, 2010.

FIRST YEAR - SEMESTER – II

Course Title	**Thermodynamics and Statistical Mechanics**								
Course Type	Hard Core- Theory		Total Hours	48	Hours/Week		03	Credits	03
Course Code	**B0230**	Evaluation	Internal	C1+C2 = 15+15				30 Marks	100
			External	C3	Duration	03Hrs		70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	explain various physical phenomena and processes observed in nature related to temperature and energy.
CO-2	analyse physical problems at the atomic level.
CO-3	understand the laws and formalism of thermodynamics.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	be able to solve statistical mechanics problems for simple non-interacting systems.	PSO-4	Apply
CLO-2	explain statistical physics and thermodynamics as logical consequences of the postulates of statistical mechanics.	PSO-1 PSO-2	Understand
CLO-3	will be able to understand the behaviour of particles using distribution functions.	PSO-1 PSO-2	Understand

Course Outline

UNIT-I	**Thermodynamics**	**16hrs**
1.1	Maxwell's thermodynamic relations, thermodynamic potentials	
1.2	Expression for specific heat.	
1.3	The third law of thermodynamics	
1.4	Thermodynamic description of phase transitions - phase equilibria, equilibrium conditions	
1.5	Classification of phase transitions, phase diagrams	
1.6	Clausius-Clapeyron equation and applications	
1.7	Van der Waal's equation of state [Ref.1]	
	Key words: Potentials, phase transitions	

UNIT-2	**Classical statistical physics**	**16hrs**
2.1	**Classical statistical mechanics**[Ref.2,3]	
2.1.1	Phase space, division of phase space into cells	
2.1.2	Ensembles, Ergodic hypothesis	
2.1.3	Average values in phase space, density distribution in phase space	
2.1.4	Liouville theorem, statistical equilibrium,	
2.1.5	Postulate of equal apriori probability, Stirling approximations, concept of probability	
2.1.6	Microstates and macrostates	
2.1.7	Microcanonical ensemble, canonical ensemble, grand canonical ensemble	
2.1.8	General expression for probability, the most probable distribution	
2.1.9	Maxwell-Boltzmann distribution, partition function of system of particles	
2.1.10	Translational partition function (monoatomic), vibrational partition function of diatomic molecules (Einstein relations), rotational partition function (diatomic)	
2.1.11	Electronic partition function- Boltzmann theorem of equipartition of energy, application to heat capacities of gases and solids	
	Key words: Phase space, ensembles, partition functions	

UNIT-3	**Quantum statistical physics**	**16hrs**
3.1	**Quantum statistical mechanics**[Ref.2,3]	
3.1.1	The postulates of quantum statistical mechanics, symmetry of wave functions	
3.1.2	Condition for statistical equilibrium, ensembles in quantum mechanics.	
3.1.3	The quantum distribution functions - Bose Einstein and Fermi Dirac, the derivation of the corresponding distribution functions	
3.1.4	The Boltzmann limit of Boson and Fermion gases	
3.2	**Applications of quantum statistics**[Ref.2,3]	
3.2.1	Equation of state of an ideal Fermi gas (derivation not expected)	
3.2.2	Application of Fermi-Dirac statistics to the theory of free electrons in metals - Fermi energy, electronic specific heat	
3.2.3	Application of Bose Einstein statistics to the photon gas - derivation of Planck's law, comments on the rest mass of photon, Bose-Einstein condensation	
	Key words: Quantum statistics, black body radiation	

References

1 Huang K., Statistical Mechanics, 3rdEdn., Wiley-Eastern, 2013.

2 Laud B.B., Fundamentals of Statistical Mechanics, 2ndEdn., New Age International Pub., India, 2012.

3 Agarwal B.K. and Eisner M., Statistical Mechanics, 3rdEdn., New Age International Pub., India, 2013.

4 Roy S.K., Thermal Physics and Statistical Mechanics, New Age International (P) Limited,

Publishers, New Delhi., India, 2000.
5 Gopal E.S.R., Statistical Mechanics and Properties of Matter, Ellis Horwood Ltd., UK, 1976.
6 Schroeder D.V., An Introduction to Thermal Physics, Pearson Education, New Delhi, 2008.
7 Salinas S.R.A., Introduction to Statistical Physics, Springer, (India) Private limited, 2004.

FIRST YEAR - SEMESTER – II

Course Title	**Optics Lab**							
Course Type	Hard Core- Practical		Total Hours	128	Hours/Week	08	Credits	04
Course Code	**BP210**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100
			External	C3	Duration	03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	develop skills in use of advanced optical equipment's to study these phenomena and verify laws of optics.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	set up and operate advanced experiments in optics.	PSO-3 PSO-4	Apply
CLO-2	study and verify different optical phenomena.	PSO-3 PSO-4	Apply

Course Outline

Any eight of the following experiments:

1 Verification of the Brewster's law of polarization.
2 Verification of Fresnel laws of reflection from a plane dielectric surface.
3 Birefringence of mica using Babinet compensator.
4 Birefringence of mica by using the quarter-wave plate.
5 Experiments with Michelson interferometer.
6 Determination of the size of lycopodium spores by the method of diffraction haloes.
7 Determination of the wavelength of light by using the Fabry-Perot etalon.
8 Verification of Malus' law.
9 Experiments with source laser.
10 Study of elliptically polarized light.
11 Determination of the refractive index of air by Jamin interferometer.
12 Determination of Stokes vector of a partially polarized light beam.
13 Determination of thickness of mica sheet using Edser Butler Fringes.
14 Determination of wavelength of He-Ne laser by Michelson interferometer.
15 Diffraction of laser light by single slit and diffraction grating
a) determination of wavelength of laser,
b) determination of distance between two slits using interference of laser light through double slit.

FIRST YEAR - SEMESTER – II

Course Title	General Physics Lab								
Course Type	Hard Core- Practical		Total Hours	64	Hours/Week	04	Credits	03	
Course Code	**BP220**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100	
			External	C3	Duration	03Hrs	70 Marks		

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	develop skills in the design and conduction of experiments to demonstrate physical laws and phenomena.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	set up, and carry out basic and advanced experiments in different areas of physics.	PSO-3 PSO-4	apply

Course Outline

Any eight of the following experiments:

1 Determination of the modes of vibration of a fixed-free bar.
2 The Franck-Hertz experiment.
3 Electron spin resonance.
4 Analysis of spectroscopic data.
5 Zeeman effect.
6 Verification of law of intermediate metals.
7 Determination of inversion temperature of a thermocouple.
8 Estimation of birefringence of quartz.
9 Determination of molecular polarizability of liquids and solutions.
10 Birefringence of crystals by prism technique.
11 Absorption coefficient of solutions.
12 Determination of Stefan’s constant using photovoltaic cell.
13 Calibration of silicon diode and copper constantan thermocouple as temperature sensors.
14 Determination of velocity of ultrasonic waves using mechanical method.
15 Optical rotatory dispersion of quartz

FIRST YEAR - SEMESTER – II

Course Title	Electronics Lab								
Course Type	Hard Core- Practical		Total Hours	128	Hours/Week	08	Credits	03	
Course Code	**BP230**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100	
			External	C3	Duration	03Hrs	70 Marks		

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	design and conduct analog electronics experiments using opamp IC 741C.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	analyze and design circuits employing integrated-circuit operational amplifiers.	PSO-3 PSO-4	Analyze

Course Outline

Any eight of the following experiments:

1 Regulated power supply.
2 Op-amp characteristics.
3 Op-amp as inverting and non-inverting amplifier.
4 Op-amp as summing and difference amplifier.
5 Op-amp voltage follower.
6 Op-amp active filters: low pass and high pass (first order).
7 Op-amp active filters: low pass and high pass (second order).
8 Op-amp as integrator and differentiator.
9 Op-amp phase shift oscillator.
10 Op-amp Wein bridge oscillator.
11 Encoder and decoder.
12 Verification of Boolean laws.
13 Half adder and full adder, half subtractor and full subtractor.
14 RS and JK flip-flops.

FIRST YEAR - SEMESTER – II

Course Title	**Liquid Crystals**								
Course Type	Soft Core- Theory		Total Hours	48	Hours/Week	03		Credits	03
Course Code	**B0310**	Evaluation	Internal	C1+C2 = 15+15				30 Marks	100
			External	C3	Duration		03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	elucidate basic as well as advanced topics of liquid crystals.
CO-2	measure physical properties, chemical structure and theories of liquid crystals.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	describe lyotropic, nematic and smectic A & C thermotropic liquid crystals.	PSO-2	Understand

CLO-2	predict whether it will exhibit liquid crystalline behaviour based on the structure of a molecule.	PSO-4	Apply

Course Outline

UNIT-1 Anisotropic fluids — 16hrs

1.1 Main types and properties, the building blocks, small organic molecules, long helical rods, associated structures, nematics - nematics proper, static pre-transitional effects above T_{N-I}

1.2 Cholesterics - a distorted form of the nematic phase, smectics - smectic A, smectic B, smectic C, other smectic phases, exotic smectics

1.3 Long range order in a system of long rods, lyotropic systems. [Ref.1-3]

1.4 Remarkable features of liquid crystals, applications of liquid crystals in devices like thermometers, calculators, TFT displays, etc. [Ref. 4]

Key words: Cholesterics

UNIT-2 Nematics and smectics — 16hrs

2.1 Long and short range order in nematics

2.1.1 Definition of an order parameter, microscopic approach, order parameter from optical method and from diamagnetic anisotropy, mean field theory with S2 interaction (Maier-Saupe). [Ref.1, 2]

2.2 Static distortion in nematics

2.2.1 Long range distortions, distortion free energy, magnetic field effects -molecular diamagnetism, magnetic coherence length. [Ref.1,2]

2.3 Defects and textures in nematics

2.3.1 Observation, black filaments, schlieren structures, types of defects (qualitative). [Ref.1,2]

2.4 **Smectics:** Continuum description of smectics A and C, mean field description of SmA -N transition. [Ref.1,2]

Key words: Nematics, Smectics, Cholesterics

UNIT-3 Nematics and cholesterics — 16hrs

3.1 Dynamical properties of nematics:

3.1.1 Experiments measuring the Leslie coefficients - laminar flow under a strong orienting field, attenuation of ultrasonic shear waves, laminar flow in the absence of external fields

3.1.2 Convective instabilities under electric fields - basic electrical parameters, experimental observations at low frequencies, the Helfrich interpretation, extension to higher frequencies (qualitative). [Ref.1,2]

3.2 Cholesterics

3.2.1 Optical properties of an ideal helix - the planar texture, Bragg reflection, transmission properties at arbitrary wavelengths (normal incidence), the Mauguin limit, rotatory power, agents influencing the pitch - physicochemical factors, external fields (qualitative), textures in cholesterics. [Ref.1,2]

Key words: Nematics, Smectics, Cholesterics

References

1. de Gennes P.G. and Prost J.,The Physics of Liquid Crystals,2nd Edn., Clarendon Press, Oxford,1998.
2. Chandrashekhar S., Liquid Crystals, CambridgeUniversityPress, 1977.
3. Gray G.W.and Goodby J.W.,Smectic Liquid Crystals: Textures and Structures, LeanardHill,

London, 1984.
4 Maier G.,Sackmann E.and GrabmanierI.G.,Applications of Liquid Crystals, Springer Verlag, 1975.
5 Gray G.W., Molecular Structure and the Properties of Liquid Crystals, AcademicPress, 1962.

FIRST YEAR - SEMESTER – II

Course Title	**Biophysics**								
Course Type	Soft Core- Theory		Total Hours	48	Hours/Week	03	Credits	03	
Course Code	**B0510**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100	
			External	C3	Duration	03Hrs	70 Marks		

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	learn selected biological phenomena using physical principles.
CO-2	understand the building blocks of biological molecules and their structure.
CO-3	understand the fundamental aspects of biological problems at the molecular level.
CO-4	learn selected biological phenomena using physical principles.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	apply key principles of biophysics toward evaluating and analyzing primary literature in the field.	PSO-2	Apply
CLO-2	explain key concepts in physiology and biophysics (and supporting disciplines).	PSO-5	Understand
CLO-3	elucidate the structure of biological molecules.	PSO-5	Analyze

Course Outline

Offered to post-graduate students of Physics and Biochemistry

UNIT-1 Biophysics and thermodynamics — 16hrs

1.1 **Introduction**[Ref.1]

1.1.1 The broad characteristics of a typical cell, cell organelles, the molecular composition of a cell

1.1.2 Biological molecules and their general character, cell behaviour, viruses, genetics and biophysics

1.2 **Molecular physics**[Ref.1]

1.2.1 The conservation of energy in biological process, metabolism or chemical energy turnover

1.3 **Statistical thermodynamics and biology**[Ref.1]

1.3.1 The theory of absolute reaction rates, thermal inactivation, the entropy transfer of living organisms

1.4 **Information theory** [Ref.1]

1.4.1 Relation between entropy and biological systems, content of a bacterial cell

Key words: Biomolecules, metabolism, thermodynamics

UNIT-2 Structure analysis of biomolecules — 16hrs

2.1 Determination of size and shape of molecules[Ref.1]

2.1.1 Introduction - random motion, diffusion, sedimentation, Optical methods: rotational diffusion and birefringence

2.2 X-ray analysis and molecular structure[Ref.1]

2.2.1. Diffraction of X-rays, crystal structure and the unit cell

2.2.2 Diffraction patterns of some protein fibers

2.2.3 The structure of globular proteins

2.2.4 The structure of polypeptide chains - the pleated sheets and beta-keratin, the alpha-helix and alpha-keratin

2.2.5 The structure of nucleic acid polymers, the structure of nucleoproteins, the analysis of virus structures

Key words: molecular structure, small molecules

UNIT-3 Molecular spectroscopy — 16hrs

3.1 Absorption spectroscopy and molecular structure[Ref.1]

3.1.1 Vibrations of polyatomic molecules, characteristic bond frequencies

3.1.2 Raman spectra and the dipolar nature of amino acids

3.1.3 The vibrational spectra of proteins, the energy levels of hydrogen bonded structures

3.1.4 Absorption coefficient and cross section

3.1.5 Experimental techniques for absorption measurements, absorption by oriented dipoles, dichroic ratios of proteins and nucleic acids, electronic spectra of polyatomic molecules

3.1.6 Ultraviolet absorption by proteins and nucleic acids, the fine structure in spectra, polarised ultra violet light spectroscopy

3.1.7 Electron spin resonance (qualitative), nuclear magnetic resonance (qualitative)

Key words: Absorption and molecular spectroscopy

References

1 Setlow R.B. and Pollard E.C., Molecular Biophysics, Pergamon Press, London-Paris, 1962.
2 Volkenshtein M.V., Biophysics, Mir Publishers, Moscow, 1983.
3 Sarn K., Biophysics, Rajat Publications, India, 2005.
4 Rodney C., Biophysics: An Introduction, Johy-Wiley & Sons, 2003.
5 Glaser R., Biophysics, An Introduction, Springer, 2004.
6 Nihaluddin, Textbook of Biophysics, Sonali Publications, New Delhi, 2009.

FIRST YEAR - SEMESTER – II

Course Title	Materials Science						
Course Type	Soft Core- Theory	Total Hours	48	Hours/Week	03	Credits	03

Course Code	B0520	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100
			External	C3	Duration	03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	understand basic principles and implementation of material structure, processing, properties and performance of different classes of materials.
CO-2	expand their knowledge in specialized areas at the forefront of materials development.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	relate theoretical knowledge to modern materials physics.	PSO-2	Understand
CLO-2	the techniques of preparing and fabricating ceramic materials	PSO-5	Understand

Course Outline

Offered to post-graduate students of Physics and Chemistry

UNIT-1 Introduction — 16hrs

1.1 Introduction to materials[Ref.1-3]

1.1.1 Classification of materials **-** levels of structure, structure-property relationship in materials**.** crystalline and amorphous materials

1.1.2 High T_c super conductors, alloys and composites, semiconductors

1.1.3 Solar energy materials, luminescent and optoelectronic materials, polymer

1.1.4 Liquid crystals and quasi crystals, ceramics-types, properties and applications

1.2 Structure of solids [Ref.1-3]

1.2.1 The crystalline and non-crystalline states

1.2.2 Covalent solids, metals and alloys, ionic solids, the structure of silica and silicates

Key words: Materials, liquid crystals, nano materials

UNIT-2 Material preparation and synthesis — 16hrs

2.1 Preparation techniques of materials[Ref.1-3]

2.1.1 **S**ingle crystal growth, zone refining, epitaxial growth

2.1.2 Melt-spinning and quenching methods, sol-gel, polymer processing

2.1.3 Preparation of ceramic materials, fabrication, control and growth modes of organic and inorganic thin films: different techniques of thin film preparations - basic principles

2.2 Synthesis of nanomaterials[Ref.1-3]

2.2.1 Top down and bottom up approaches of synthesis of nano-structured materials (Solution combustion method, Sol-gel, hydrothermal, LASER ablation)

2.2.2 Nanorods, nanotubes/wires and quantum dots

2.2.3 Fullerenes and tubules, single wall and multiwall nanotubes

Key words: crystal growth, synthesis

UNIT-3 Phase Transition — [16hrs]

3.1 Solid phases and phase diagrams[Ref.1-3]

3.1.1 Single and multiphase solids, solid solutions and Hume-Rothery rules

3.1.2 Intermediate phase, the inter metallic and interstitial compounds

3.1.3 Properties of alloys: solid solutions and two component alloy systems

3.1.4 Phase diagram, Gibbs phase rule, lever rule- first, second and third order phase transitions with examples

3.1.5	Some typical phase diagrams: Pb-Sn, Ag-Pt and Fe-Fe_3C, eutectic, eutectoid, peritectic and peritectoid systems	.
3.1.6	Order disorder phenomenon in binary alloys, long range order, super lattice, short range order	
3.2	**Phase transformation**[Ref.1-3]	
3.2.1	Time scale for phase changes	
3.2.2	Nucleation and growth, nucleation kinetics, growth and overall transformation kinetics	
3.2.3	Applications - transformation in steel- precipitation processes, solidification and crystallization- glass transition, recovery, recrystallization and grain growth	

Key words: Alloys, phase diagrams, phase transformation

Reference Books

1 Van Vlack L. H., Elements of Materials Science and Engineering, 6th Edn. Addison Wesley, 1989.
2 Raghvan V., Materials Science and Engineering, 5th Edn. Prentice Hall of India, 2009.
3 HazraChaudary S. K., Materials Science and Processes, Indian Book Distr. Co., 1977.
4 Chopra K. L., Thin Film Phenomena, Robert E K Publishing Company, 1979.
5 Budinski K. G. and Budinski M. K., Engineering Materials, 8th Edn. Prentice-Hall of India Pvt. Ltd, 2004.

SECOND YEAR - SEMESTER – III

Course Title	**Condensed Matter Physics**								
Course Type	Hard Core- Theory		Total Hours	48	Hours/Week	03	Credits	03	
Course Code	**C0210**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100	
			External	C3	Duration	03Hrs	70 Marks		

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	explore the rich behaviour of solid systems under a wide range of conditions.
CO-2	analyze the crystal structure using X-ray, electron and neutron diffraction techniques.
CO-3	understand the magnetic properties of solids, semiconductors and superconductors.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	find the structure of small and macro molecules.	PSO-1	Understand
CLO-2	explain material response to external magnetic field.	PSO-2	Understand
CLO-3	design components using semiconducting material.	PSO-5	Create

Course Outline

UNIT-1 Crystal geometry I — 16hr

1.1 **X-ray crystallography** [Ref.1,2]

1.1.1 Crystalline state, reference axes, equation of a plane

1.1.2 Miller indices, symmetry operations- two and three dimensional lattices and point groups

1.1.3 Crystal systems and Bravais lattices, screw and glide operations

1.1.4 Space groups, analysis of the space group symbol.

1.1.5 Diffraction of X-rays by crystals: Laue equations, reciprocal lattice, Bragg equation, equivalence of Laue and Bragg equations

1.2 Experimental techniques[Ref.2,3]

1.2.1 A brief introduction to Laue, oscillation, Weissenberg, powder and counter methods.

1.3 Crystal growth[Ref.4,5]

1.3.1 Crystal growth from melt: Bridgemann technique, Czochralski's method

1.3.2 Growth from solutions, zone refining method of purification

1.4 Electron and neutron diffraction[Ref.4]

1.4.1 Basic principles, differences between them and X-ray diffraction, applications (qualitative)

Keywords: crystal, diffraction

UNIT-2 Lattice vibrations and magnetic properties of solids **16hrs**

2.1 Crystal lattice dynamics[Ref.6]

2.1.1 Vibration of an infinite one-dimensional monoatomic lattice, first Brillouin zone, group velocity, finite lattice and boundary conditions

2.1.2 Vibrations of a linear diatomic lattice - optical and acoustical branches, experimental measurements of dispersion relation, anharmonicity and thermal expansion

2.2 Magnetic properties of solids

2.2.1 Diamagnetism and its origin, expression for diamagnetic susceptibility

2.2.2 **Paramagnetism**: quantum theory of paramagnetism, Curie's law, Brillouin function.

2.2.3 **Ferromagnetism**: quantum theory of Ferromagnetism, Curie-Weiss law, spontaneous magnetisation and its variation with temperature, ferromagnetic domains

2.2.4 **Antiferromagnetism**: two sub-lattice model, susceptibility below and above Neel's temperature. [Ref.7]

Keywords: lattice dynamics, magnetic properties

UNIT-3 Semiconductor and Superconductivity **16hrs**

3.1 Semiconductors

3.1.1 **Intrinsic semiconductors:** expressions for electron and hole concentrations, intrinsic carrier concentration, effect of temperature. Fermi energy, electrical conductivity and experimental determination of energy gap

3.1.2 **Extrinsic Semiconductors**: carrier concentrations, effect of temperature and impurity density. Fermi energy - Fermi energy when the Boltzmann approximation is valid for electron and holes, Fermi energy at very low temperatures, effect of impurity density. Electrical conductivity - expression for electrical conductivity, effect of temperature and impurity concentration. [Ref.8]

3.2 Superconductivity[Ref.9]

3.2.1 Experimental facts, type I and type II superconductors, phenomenological theory- London equations

3.2.2 Meissner effect, High frequency behavior

3.2.3 Thermodynamical theory of superconductors, entropy and specific heat in the superconducting state

Keywords: semiconductors, superconductors

References

1 Ladd M.F.C. and Palmer R.A., Structure Determination by X-ray Crystallography, PlenumPress, USA, 1977.

2 BuergerM.J.,ElementaryCrystallography,AcademicPress,UK,1956.
3 Sherwood D., Crystals, X-rays and Proteins, Longman, UK, 1976.
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7 Dekker A.J., Solid State Physics, Macmillan India Ltd., New Delhi, 2008.
8 Mckelvey J.P., Solid State and Semiconductor Physics, 2nd Edn., Harper and Row, USA, 1966.
9 Kittel C., Introduction to Solid State Physics, 7th Edn. John Wiley, New York, 1996.
10 Pillai S.O., Solid State Physics, New Age International, 2006.

SECOND YEAR - SEMESTER – III

Course Title	**Nuclear and Particle Physics**								
Course Type	Hard Core- Theory		Total Hours	48	Hours/Week		03	Credits	03
Course Code	**C0220**	Evaluation	Internal	C1+C2 = 15+15				30 Marks	100
			External	Duration	C3	03Hrs		70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	understand the basic structure, properties of atomic nucleus.
CO-2	understand various nuclear decays modes and models.
CO-3	understand Interaction of nuclear radiation with matter and various nuclear reactions.
CO-4	understand physics of elementary particles.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	Understand the importance of models in describing the properties of nuclei and nuclear interactions.	PSO-1 PSO-2	Understand
CLO-2	analyze the nuclear decay modes .	PSO-3	Analyze
CLO-3	Be familiar with main theoretical concepts and experimental techniques used in elementary particle physics.	PSO-1	Understand
CLO-3	Be able to make quantitative estimates of phenomena involving nuclei.	PSO-4 PSO-5	Apply

Course Outline

UNIT-1 Nuclear properties and models **16hrs**

1.1 Properties of the nucleus

1.1.1 Nuclear radius - determination by mirror nuclei, Mesic X-rays and electron scattering methods

1.1.3 Nuclear moments: spin, magnetic dipole moment

1.1.3 Relation between J and μ on the basis of single particle model

1.1.4 Determination of nuclear magnetic moment by Rabi's molecular beam experiment Electric quadrupole moment [Ref.1,2]

1.2 **Nuclear models**

1.2.1 Liquid drop model: Weissacker's formula and its application to (i) stability of isobars and (ii) fission process

1.2.2 Fermi gas model: well depth, level density and nuclear evaporation. [Ref.1,2].

1.2.3 Shell model: single particle potentials, spin-orbit coupling, magic numbers

1.3 **Nuclear reactions**

1.3.1 Q-values, threshold energy, reactions induced by proton, deuteron and other particles, photodisintegration. [Ref.1,2].

Keywords: Nuclear properties, nuclear models, nuclear reactions

UNIT-2 Radioactivity, radiations and reactors **16hrs**

2.1 **Nuclear decay modes**

2.1.1 Beta decay: Beta ray spectrum, Pauli neutrino hypothesis, mass of the neutrino from beta ray spectral shape

2.1.2 Fermi theory of beta decay, Kurie plot, ft- values and forbidden transitions

2.1.3 Methods of excitation of nuclei, nuclear isomerism, Mossbauer effect, Auger effect (qualitative) [Ref.3].

2.2 **Interaction of nuclear radiation with matter and detectors**

2.2.1 Energy loss due to ionization for proton-like charged particles, Bethe-Bloch formula

2.2.2 Range-energy relations

2.2.3 Ionization and radiation loss of fast electrons (Bremsstrahlung) (qualitative)

2.2.4 Interaction of gamma and X-rays with matter, brief description of NaI (Tl) gamma ray spectrometer, boron triflouride counter. [Ref.3,4].

2.3 **Nuclear reactors**

2.3.1 Condition for controlled chain reactions, slowing down of neutrons, logarithmic decrement in energy, homogeneous spherical reactor, critical size, effect of reflectors, breeder reactor (qualitative). [Ref.3].

Keywords: Nuclear transitions, Radiation protection, reactor theory

UNIT-3 Particle Physics **16hrs**

3.1 **Nuclear forces and elementary particles**

3.1.1 General features of nuclear forces: spin dependence, charge independence, exchange character, etc..

3.1.2 Meson theory of nuclear forces - Yukawa's theory

3.1.3 Properties of pi mesons - charge, isospin, mass, spin and parity, decay modes, meson resonances. [Ref.2]

3.2 **Particle interactions and families**

3.2.1 Conservation laws

3.2.2 Classification of fundamental forces and elementary particles

3.2.3 Associated particle production, Gellmann-Nishijima scheme, strange particles

3.2.3 CP violation in Kaon decay

3.2.4 Symmetries: eight-fold way symmetry, quarks and gluons

3.2.5 Elementary ideas of the standard model. [Ref.2].

Keywords: Nuclear forces, high energy physics, subatomic particles

References

1 Tayal D.C., Nuclear Physics, Himalaya Publishing House, New Delhi, 2012.

2 Krane K.S., Introductory Nuclear Physics, Wiley, New York, 1987.

3 Ghoshal S.N., Nuclear Physics, S. Chand and Company, Delhi, 1994.

4 Kapoor S.S. and Ramamoorthy V., Nuclear Radiation Detectors, Wiley Eastern, Bangalore,2007.

5 Wong S.S.M., Introductory Nuclear Physics, Prentice Hall of India, Delhi, 1998.

6 Khanna M.P., Introduction to Particle Physics, Prentice Hall of India, Delhi, 2008.

SECOND YEAR - SEMESTER – III

Course Title	**Condensed Matter Physics Lab**							
Course Type	Hard Core- Practical		Total Hours	128	Hours/Week	08	Credits	04
Course Code	**CP210**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100
			External	C3	Duration	03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	setup and demonstrate experiments that are selected from areas such as magnetic properties, semiconductor physics and X-ray crystallography.
CO-2	observe the behaviours of matter in a lab environment.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs)** **On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	analyse the given x-ray diffraction data.	PSO-3	Analyze
CLO-2	determine the type of semiconducting materials and their properties.	PSO-5	Evaluate

Course Outline

Any eight of the following Experiments:

1 Determination of temperature coefficient of resistance of a thermistor.
2 Determination of the paramagnetic susceptibility of the given salt by Quincke's method.
3 Determination of thermionic work function of a metal (Richardson-Dushmann formula).
4 Verification of Langmuir-Child's law.
5 Magnetic hysteresis.
6 Indexing X-ray powder diffractogram (graphical method).
7 Indexing X-ray powder diffractogram. (mathematical method)
8 Energy gap of an intrinsic semiconductor.
9 Determination of e/k_B using the given p-n junction diode.
10 Energy gap of material of photovoltaic cell.
11 Energy gap of material of photoconductive cell.
12 Optical rotatory dispersion of a uniaxial crystal.

SECOND YEAR - SEMESTER – III

Course Title	**Nuclear Physics Lab**							
Course Type	Hard Core- Practical		Total Hours	128	Hours/Week	08	Credits	04
Course Code	**CP220**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100
			External	C3	Duration	03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	perform experiments selected from different areas of Nuclear Physics such as nuclear decay, nuclear spectroscopy and nuclear electronics.
CO-2	verify some of the concepts learnt in the theory course of Nuclear and Particle Physics.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs)** **On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	perform advanced nuclear electronics experiments independently.	PSO-3 PSO-5	Create
CLO-2	perform and analyse experiments using gamma ray spectrometer.	PSO-3 PSO-5	Evaluate

Course Outline

Any eight of the following experiments:

1 Dead time of GM counter by two source method.
2 Randomocity of radioactive decay.
3 Beta absorption coefficient measurement.
4 Gamma ray spectrometer.
5 Gamma-ray absorption coefficient measurement.
6 Schmitt trigger.
7 Coincidence circuit.
8 FET common source amplifier.
9 Astable multivibrator using timer IC 555.
10 Clippers and clampers.
11 Op-amp inverting amplifier-frequency response.

SECOND YEAR - SEMESTER – III

Course Title	**Condensed Matter Physics 1**							
Course Type	Soft Core- Theory		Total Hours	48	Hours/Week	03	Credits	03
Course Code	**C0310**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100
			External	C3	Duration	03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	describe various physical properties of solid materials.
CO-2	differentiate materials based on their energy bands.
CO-3	understand semiconducting material types, their principle of working and applications.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	understand and define electrical and thermal properties of materials.	PSO-1 PSO-3	Understand
CLO-2	understand the physics of semiconductors and design components using semiconducting material.	PSO-1 PSO-2	Understand

UNIT-1 Free electron theory of metals — 16hrs

1.1 Boltzmann transport equation
1.2 Sommerfeld's theory of electrical conductivity
1.3 Mean free path in metals
1.4 Dependence of resistivity on temperature and impurities, Matthiessen's rule, electron-phonon collisions, thermal conductivity of insulators, Umklapp processes. [Ref.1,3]
1.5 Electrical conductivity of metals at high frequencies, plasma frequency
1.6 Transparency of alkali metals to UV radiation, anomalous skin effect, plasmons, field enhanced emission, Schottky effect
1.7 Hall effect and magnetoresistance in metals, cyclotron frequency. [Ref.2]

Keywords: metallic properties

UNIT-2 Band theory of solids — 16hrs

2.1 Statement and proof of Bloch theorem, explanation of periodic potentials in solids
2.2 Construction of Brillouin zones for a square lattice, nearly free electron model and solution at the boundary, discussion of energy gap using nearly free electron model, tightly bound electron approximation - application to simple cubic, BCC and FCC lattices [Ref.1, 2, 3]
2.4 Semiconductors
2.4.1 Hall effect in semiconductors - expression for Hall coefficient in terms of mobility of current carriers and carrier densities, Hall mobility and Hall factor
2.4.2 Effect of temperature, impurity concentration and magnetic field, magneto-resistance phenomenon (qualitative). [Ref.3]
2.5 Cyclotron resonance
2.5.1 Cyclotron resonance in Si and Ge semiconductors, effective mass tensor, variation of

cyclotron resonance frequency with orientation of the crystal in the magnetic field. [Ref.3]

Keywords: band theory, semiconductor

UNIT-3 Semiconductors **16hrs**

3.1 High field transport

3.1.1 Concept of hot electrons, expression for electron temperature, Gunn effect

3.1.2 Negative differential conductance (NDC), mechanism responsible for NDC with a special reference to n-GaAs. [Ref.3]

3.2 Excess carriers in semiconductors

3.2.1 Generation and recombination rates, excess carriers, continuity equations for excess carriers

3.2.2 Einstein equations, expression for the diffusion length of electrons and holes. [Ref.3]

3.3 Diodes and transistors

3.3.1 **Diodes** : Theory, formation of space charge region, expressions for barrier potential, barrier thickness and contact field, effect of the applied field on the above junction parameters, transition capacitance associated with the space-charge region, expressions for current densities using continuity equations for excess carriers, depletion capacitance

3.3.2 **Transistors** –a brief discussion on the dc current gain, α and β cut-off frequencies [Ref.3]

Keywords: semiconductors, diod**e**

References

1 Dekker A.J., Solid State Physics, Macmillan India Ltd., New Delhi, 2008.
2 Kittel C., Introduction Solid State Physics, 7thEdn.John Wiley, New York, 1996.
3 Mckelvey J.P., Solid State and Semiconductor Physics, 2ndEdn. Harper and Row, USA, 1966.
4 Wilson J. and Hawkes J.F.B., Optoelectronics - An Introduction, 2ndEdn. Prentice-Hall of India, New Delhi, 1996.
5 Streetman B.G., Solid State Electronic Devices, 2ndEdn. Prentice-Hall of India, New Delhi, 1983.
6 Wahab M.A., Solid State Physics, Narosa Publishing House, New Delhi, 1999.
7 Roy D.K., Physics of Semiconductor Devices, University Press, Hyderabad, 1992.
8 Schur M., Physics of Semiconductor Devices, Prentice-Hall of India, New Delhi, 1999.
9 Omar M.A., Elementary Solid State Physics, Addison Wesley, New Delhi, 2000.

SECOND YEAR - SEMESTER – III

Course Title	Condensed Matter Physics Lab 1								
Course Type	Soft Core- Practical		Total Hours	128	Hours/Week	08	Credits	04
Course Code	CP310	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100
			External	C3	Duration	03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	setup and demonstrate experiments that are selected from areas such as magnetic properties, semiconductor physics and X-ray crystallography.
CO-2	observe the behaviours of matter in a lab environment.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	analyse the given x-ray diffraction data.	PSO-3	Analyze
CLO-2	determine the type of semiconducting materials and their properties.	PSO-5	Evaluate

Course Outline

Any eight of the following experiments:

1 Determination of Fermi energy of copper
2 Determination of material constant of an intrinsic semiconductor
3 Energy gap of the semiconductor by studying the temperature variation of the junction voltage in the case of a p-n junction diode
4 Determination of magnetoresistance of given semiconductor
5 Determination of Hall coefficient of given semiconductors
6 Temperature variation of Hall coefficient
7 Indexing X-ray powder diffractogram of cubic crystals (analytical method)
8 Indexing X-ray powder diffractogram of non-cubic crystals
9 Determination of ultrasonic velocity and elastic constants of a solid
10 Calculation of thermal expansion coefficient in solids
11 Temperature variation of dielectric constant and determination of Curie point of a ferroelectric material

SECOND YEAR - SEMESTER – III

Course Title	**Nuclear Physics 1**							
Course Type	Soft Core- Theory		Total Hours	48	Hours/Week	03	Credits	03
Course Code	**C0320**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100
			External	C3	Duration	03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be :
CO-1	familiar with nuclear detectors, nuclear electronics and nuclear spectroscopic techniques which play a main role in experimental nuclear and particle physics, and expose them to theories of various nuclear models.

Mapping of CLOs with PSOs &CDLs

CLOs No.	Course Learning Outcomes (CLOs) On completion of the course the student will learn to :	PSOs Addressed	CLDs
CLO-1	describe the nuclear interactions with matter and their detection.	PSO-4	Analyze
CLO-2	be familiar with different nuclear models and nuclear spectroscopy.	PSO-1	Understand

UNIT-1 Nuclear electronics — 16hrs

1.1 Nuclear detectors

1.1.1 Scintillation processes in inorganic crystals [NaI(Tl)]

1.1.2 Semiconductor detectors -diffused junction, surface barrier and lithium drifted detectors

1.1.3 Relation between applied voltage and depletion layer thickness in junction detectors, hyper pure germanium (HPGe) detectors, Cerenkov detectors [Ref.1,2]

1.2 Nuclear pulse techniques

1.2.1 Preamplifier circuits, charge sensitive and voltage sensitive preamplifiers

1.2.2 Linear pulse amplifiers, linearity, stability, pulse shaping, pulse stretching

1.2.3 Operational amplifiers - analog to digital converters, scalars, Schmidt trigger as a pulse discriminator

1.2.4 Single channel analyser - integral and differential discriminators, multichannel analyzers, memory devices and online data processing [Ref.3-5]

Keywords: detectors, pulse techniques

UNIT-2 Nuclear Models — 16hrs

2.1 Shell model

2.1.1 Motion in a mean potential, square well and simple harmonic oscillator potential well

2.1.2 Spin-orbit interaction and magic numbers, extreme single particle model, ground state properties of nuclei based on shell model, Nordheim's Rules [Ref.6,7]

2.2 Collective model

2.2.1 Evidences for the collective motion, nuclear rotational motion, rotational energy spectrum and nuclear wave functions for even-even nuclei, odd-A nuclei energy spectrum and wave function [Ref.8,9]

2.3 Nilsson model

2.3.1 Nilsson diagrams [Ref.8,9]

2.4 Many body self-consistent models

2.4.1 Hartree-Fock model [Ref.4]

Keywords: nuclear models

UNIT-3 Nuclear Spectroscopy — 16hrs

3.1 Timing spectroscopy

3.1.1 Coincidence and anti-coincidence circuits, delay circuits, time to amplitude conversion: start-stop and overlap converters [Ref.10, 11]

3.2 Gamma ray spectroscopy

3.2.1 Life time measurements, gamma-gamma and beta-gamma angular correlation studies

3.2.2 Angular distribution of gamma rays from oriented nuclei, polarization of gamma rays [Ref.10]

Keywords: Life time measurements

References

1 Kapoor S.S. and Ramamoorthy V., Nuclear Radiation Detectors, Wiley Eastern, Bangalore, 1993.
2 Kowalski E., Nuclear Electronics, Springer Verlag, Berlin, 1970.
3 Leo W.R., Techniques for Nuclear and Particle Physics Experiments, Springer Verlag, 1992.
4 Roy R.R. and Nigam B.P., Nuclear Physics, New Age International, New Delhi, 1986.
5 Hans H.S., Nuclear Physics - Experimental and Theoretical, New Age International Publishers, 2001.
6 Mermier P. and Sheldon E., Physics of the Nuclei and Particles, Vol. 1 and 2, Academic Press, New York 1970.
7 Segre E., Nuclei and Particles, Benjamin Inc., New York, 1977.
8 Arya A.P., Fundamentals of Nuclear Physics, Allyn and Bacon, USA, 1968.
9 Blatt J.M. and Weisskopf V.F., Theoretical Nuclear Physics, Wiley and Sons, New York, 1991.
10 Siegbahn K., The Alpha, Beta and Gamma Ray Spectroscopy: Vol. 1 and 2, North Holland, Amsterdam, 1965.
11 Price J.W., Nuclear Radiation Detectors, McGraw Hill, New York, 1965.

SECOND YEAR - SEMESTER – III

Course Title	**Nuclear Physics Lab 1**							
Course Type	Soft Core- Practical		Total Hours	128	Hours/Week	08	Credits	04
Course Code	**CP320**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100
			External	C3	Duration	03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	perform experiments selected from different areas of Nuclear Physics such as nuclear decay, nuclear spectroscopy and nuclear electronics.
CO-2	verify some of the concepts learnt in the theory course of Nuclear and Particle Physics.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	perform advanced nuclear electronics experiments independently.	PSO-3	Analyze
CLO-2	perform and analyse experiments using scintillation detectors and MCA.	PSO-5	Evaluate

Course Outline

Any eight of the following experiments:

1 Cockroft-Walton voltage multiplier.
2 Linear pulse amplifier.
3 Transistorised binary circuit.
4 Pulse shaping circuits.
5 Linear gate.
6 Nomogram method: measurement of endpoint energy of beta particles.
7 Study of linearity of the NaI(Tl) gamma ray spectrometer with SCA and hence determination of energy of unknown gamma source.
8 Determination of the rest mass energy of the electron using MCA.
9 Study of the variation of resolution of NaI(Tl) spectrometer as a function of energy.

Total work load: **1 day per week × 4 hours × 16 weeks** **64 hours**

SECOND YEAR - SEMESTER – III

Course Title	**Quantum Mechanics 2**							
Course Type	Hard Core- Theory		Total Hours	48	Hours/Week	03	Credits	03
Course Code	**D0210**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100
			External	Duration	C3	03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	understand time-dependent perturbation theory and its applications.
CO-2	understand theory of scattering and calculation of scattering cross section, optical theorem ,Born and partial wave analysis etc.
CO-3	Understand Relativistic Quantum Mechanics and its consequences.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs)** **On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	understand relativistic effects in quantum physics.	PSO-2 PSO-4	understand
CLO-2	evaluate quantum systems using perturbation techniques.	PSO-5	evaluate
CLO-3	be familiar with quantum scattering theory.	PSO-2 PSO-4	understand

Course Outline

UNIT-1 Perturbation Theory and its Applications **16hrs**

1.1 Time-dependent perturbation theory

1.1.1 Two level systems, the perturbed system, first order and second order equations, sinusoidal perturbations, transition probability

1.1.2 Emission and absorption of radiation - stimulated and spontaneous emission

1.1.3 Incoherent perturbations, transition rates, spontaneous emission - Einstein A and B coefficients, life time of an excited state, selection rules. [Ref.1]

1.2 The adiabatic approximation

1.2.1 Adiabatic process, Born-Oppenheimer approximation, adiabatic theorem

1.2.2 Berry's phase, non-holonomic processes, geometric phase

Keywords: approximations

UNIT-2 Scattering **16hrs**

2.1.0 Classical scattering theory - differential scattering cross section, hard sphere scattering example, the total cross section

2.2.0 Quantum scattering theory - scattering amplitude, partial wave analysis: optical theorem, the Born approximation, integral form of the Schrödinger equation, the Green's function, the first born approximation, low energy soft sphere scattering, Yukawa scattering, Rutherford scattering. [Ref.1]

2.3 Relativistic kinematics

2.3.1 Relativistic kinematics of scattering and reactions, elastic, inelastic reactions, decay of a particle: $A \to B + C, A + B \to C, P + \bar{P} \to P + \bar{P} + P + \bar{P}$ [Ref.2]

Keywords: scattering

UNIT-3 Relativistic Quantum Mechanics **16hrs**

3.1 The Klein-Gordon (K-G) equation, plane-wave solutions, negative energy states, equation of continuity, the short comings of the Klein-Gordon equation, the non-relativistic limit of the K-G equation

3.2 The Dirac equation - the free-particle Dirac equation in the Hamiltonian form, the algebra of Dirac matrices, plane wave solutions of the free-particle equation

3.3 The two-component form of the solution in the Dirac-Pauli representation, standard normalization of the solution, negative energy states and the hole theory

3.4 Non-conservation of the orbital angular momentum operator $\vec{L}$, the spin operator $\vec{S}$ and the conservation of $\vec{J} = \vec{L} + \vec{S}$, helicity operator

3.5 Dirac particle in electromagnetic field, spin-orbit interaction, the magnetic moment of the electron (non-relativistic), a brief discussion of the hydrogen atom energies according to the Dirac equation [Ref.2,3]

3.6 Field quantization- The Lagrangian formalism for a classical field; Euler-Lagrange equations. Quantization of Dirac field

Keywords: relativistic wave equations

References

1 Griffiths D.J., Introduction to Quantum Mechanics, 2nd Edn. Pearson, India, 2005.
2 Griffiths D.J., Introduction to Elementary Particles, John Wiley and Sons, New York, 2008.
3 Sakurai J.J. and Tuan S.F. (Edr.), Modern Quantum Mechanics, Addison Wesley, India, 1999.
4 Gasiorowicz S., Elementary Particle Physics, John-Wiley, New York, 1966.
5 Muirhead H., The Physics of Elementary Particles, Pergamon Press, London, 1965.

SECOND YEAR - SEMESTER – IV

Course Title	Condensed Matter Physics Lab							
Course Type	Hard Core- Practical		Total Hours	128	Hours/Week	08	Credits	04
Course Code	**DP220**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100
			External	C3	Duration	03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	setup and demonstrate experiments that are selected from areas such as magnetic properties, semiconductor physics and X-ray crystallography.
CO-2	observe the behaviours of matter in a lab environment.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	analyse the given x-ray diffraction data.	PSO-3	Analyze

CLO-2	determine the type of semiconducting materials and their properties.	PSO-5	Evaluate

Course Outline

Any eight of the following Experiments:

1 Determination of temperature coefficient of resistance of a thermistor.
2 Determination of the paramagnetic susceptibility of the given salt by Quincke's method.
3 Determination of thermionic work function of a metal (Richardson-Dushmann formula).
4 Verification of Langmuir-Child's law.
5 Magnetic hysteresis.
6 Indexing X-ray powder diffractogram (graphical method).
7 Indexing X-ray powder diffractogram. (mathematical method)
8 Energy gap of an intrinsic semiconductor.
9 Determination of e/k_B using the given p-n junction diode.
10 Energy gap of material of photovoltaic cell.
11 Energy gap of material of photoconductive cell.
12 Optical rotatory dispersion of a uniaxial crystal.

SECOND YEAR - SEMESTER – IV

Course Title	**Nuclear Physics Lab**							
Course Type	Hard Core- Practical		Total Hours	128	Hours/Week	08	Credits	04
Course Code	**DP210**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100
			External	C3	Duration	03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	perform experiments selected from different areas of Nuclear Physics such as nuclear decay, nuclear spectroscopy and nuclear electronics.
CO-2	verify some of the concepts learnt in the theory course of Nuclear and Particle Physics.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	perform advanced nuclear electronics experiments independently.	PSO-3 PSO-5	Create
CLO-2	perform and analyse experiments using gamma ray spectrometer.	PSO-3 PSO-5	Evaluate

Course Outline

Any eight of the following experiments:

1 Dead time of GM counter by two source method.
2 Randomocity of radioactive decay.
3 Beta absorption coefficient measurement.
4 Gamma ray spectrometer.

5 Gamma-ray absorption coefficient measurement.
6 Schmitt trigger.
7 Coincidence circuit.
8 FET common source amplifier.
9 Astable multivibrator using timer IC 555.
10 Clippers and clampers.
11 Op-amp inverting amplifier-frequency response.

SECOND YEAR - SEMESTER – IV

Course Title	**Minor Project Work**							
Course Type	Hard Core- Theory		Total Hours	128	Hours/Week	08	Credits	04
Course Code	**DP310**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100
			External	C3	Duration	03Hrs	70 Marks	

Objectives:
The aim of project work is to enable the students to communicate physics concepts effectively both orally and in writing and to inculcate learning spirit and research aptitude among students. It exposes the students to the principles, procedures and techniques of implementing a research project. The students learn the elementary scientific methods and acquire the skills of designing and execution of experiments, analysis and reporting of experimental data.

Students may choose one of the following areas for carrying out Minor Project:

- Liquid crystals
- X-ray crystallography
- Radiation physics
- Nanomaterials
- Nanomagnetism
- Any other area in Condensed Matter Physics / Nuclear Physics/Theoretical Physics

Project work may consist of review of some research papers, development of a laboratory experiment, fabrication of a device, working out some problem, participation in some ongoing research activity, analysis of data, etc. A student opting for this course will be attached to one teacher of the department (Project Supervisor) before the end of the 3rdsemester. This load (contact duration: 4 hours per week) will be counted towards the normal teaching load of the teacher. Topic(s) for the project may be selected in consultation with the project supervisor. Reference/Text books will be recommended by the project supervisor. The guided project is normally executed in the department laboratory, making use of the existing facilities. A few students may be allowed to take up projects in reputed research institutes depending on their performance, commitment and interesting the field of research.

A report of about 20-30 pages about the work done in the project (typed on both the sides of the paper and properly bound) will be submitted by a date to be announced by the department. Assessment of the work done under the project will be carried out by an external evaluator and project supervisor on the basis of effort put in the execution of the project, interest shown in learning the methodology, report prepared, grasp of the problem assigned and viva-voce/seminar, etc.

SECOND YEAR - SEMESTER – IV

Course Title	**Accelerator Physics**							
Course Type	Soft Core- Theory		Total Hours	48	Hours/Week	03	Credits	03
Course	**D0310**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100

Code			External	Duration	C3	03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	find applications of accelerators in X-ray science, spectrometers, electron microscopes, lithographic devices etc.
CO-2	understand theoretical aspects of charged particle beams and the technology used for their acceleration.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs)** **On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	understand how various types of accelerators work and understand differences between them	PSO-1 PSO-2	Understand
CLO-2	have a general understanding of accelerating structure	PSO-1 PSO-2	Understand
CLO-3	understand major applications of accelerators and the recent new concept	PSO-1 PSO-5	Understand

UNIT-1 Charged Particles and its Properties **16hrs**

1.1 Ion sources

1.1.1 Brief introduction to ion sources for positive and negative ions, ion production, semi classical treatment of ionization

1.1.2 Townsend theory-comparison of theory and experiment for ion production, examples of ion sources, properties of ion sources, insulation at high voltages, spark voltage.

1.1.3 Paschen's law for gas breakdown. [Ref.1,2].

1.2 Ion optics and focusing

1.2.1 Focussing properties of linear fields, electrostatic and magnetic lenses. [Ref.1,2].

Keywords: ion physics

UNIT-2 Particle Accelerators **16hrs**

2.1 Introduction, development of accelerators.

2.2 Direct-voltage accelerators: Cockroft-Walton generator, Van de Graff generator, tandem accelerators, pelletron.

2.3 Resonance accelerators: Cyclotron - fixed and variable energy, principles and longitudinal dynamics of the uniform field cyclotron. Linear accelerators. [Ref.2-4].

Keywords: cyclotron

UNIT-3 Electron accelerators **16hrs**

3.1 Betatron, beam focusing and betatron oscillation, microtron.

3.2 Synchronous accelerators: principle of phase stability, mathematical theory for principle of phase stability, electron synchrotron, proton synchrotron.

3.3 Alternating gradient machines: alternating gradient principle, AG proton synchrotron. [Ref.2-4].

Keywords: betatron, synchroton

References

1. Townsend P.D., Kelly J.C. and Hartley N.E.W., Ion Implantation, Sputtering and Their Applications, Academic Press, London, 1976.
2. Humphrey S. Jr., Principles of Charged Particle Acceleration, John Wiley, 1986.
3. Arya A.P., Fundamentals of Nuclear Physics, Allyn and Bacon, USA, 1968.
4. Ghoshal S.N., Atomic and Nuclear Physics, Vol. 2, S. Chand and Company, Delhi, 1994.
5. Varier K.M., Joseph A. and Pradyumnan P.P., Advanced Experimental Techniques in Modern Physics, PragathiPrakashan, Meerut, 2006.

SECOND YEAR - SEMESTER – IV

Course Title	**Space and Astrophysics**								
Course Type	Soft Core- Theory		Total Hours	48	Hours/Week		03	Credits	03
Course Code	**D0320**	Evaluation	Internal	C1+C2 = 15+15				30 Marks	100
			External	Duration	C3	03Hrs		70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	elucidate the concepts of space science and the universe.
CO-2	study the formation and characteristics of the solar system, including the galaxies, stars, planets; observational techniques; birth and death of star and stellar physics.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	explain the birth and death of stars.	PSO-1	Understand
CLO-2	explain the features of sun.	PSO-1 PSO-2	Understand

Course Outline

UNIT-1 Basic concepts and properties of stars **16hrs**

1.1 Basic Concepts

Trigonometric parallaxes, parsec, Apparent and absolute magnitudes, Atmospheric extinction, Angular radii of stars, Michelson's Stellar interferometer, Binary stars and their masses, Radial and transverse velocities, types of optical telescopes and their characteristics

1.2 Properties of Stars

Spectra of stars, Spectral sequence-temperature and luminosity classifications, H-R diagram, Stellar structure equations, Star formation and main sequence evolution, mass luminosity relation, Chandrasekhar limit, White dwarfs, Pulsars , Neutron stars and Black holes.

Keywords: stars

UNIT-2 The Universe and Observational techniques **16hrs**

2.1 The Solar System

The surface of the sun, solar interior structure, solar rotation, sun spots, the active sun, Properties of interior planets and exterior planets, Satellites of Planets, comets, asteroids, meteorites.

2.2 Star clusters, Galaxies and the Universe

Open and global clusters, the structure and contents of milky way galaxy, Hubble's classification of galaxies, Galactic structure and dark matter, Hubble's law, Big bang origin of the universe, cosmic microwave background radiation and evolution of the universe.

2.3 Observational techniques

Radio telescopes, detectors for X-ray and gamma rays

Keywords: solar system, galaxy

UNIT-3 Stellar Physics **16hrs**

3.1 The Sun and its emissions

Solar atmosphere, solar corona, EM radiations from the sun, solar cycles, solar energy particles, solar wind, solar flares, coronal mass ejections, The Planetary System Major characteristics of planets, bulk atmospheric composition, planetary magnetism, magnetic dipole, tilted dipole models, spherical harmonic models, magnetic fields of outer planets MHD equations, Alfven waves, Frozen in field, Planetary bow shocks, interaction with magnetized planets, plasma sources in magnetosphere, plasma acceleration, Jovian magnetosphere, plasma flow in magnetosphere

Keywords: Stellar physics

References

1 Bhatia V.B., A textbook of Astronomy and Astrophysics with Elements of Cosmology, Alpha Science International Ltd., 2001.
2 Shu F.H., Physical Universe, University Science Books, 1982.
3 Stix M., The Sun, Springer-Verlag, 1989.
4 Bohm-Vitense E., Introduction to Stellar Astrophysics, Vol.3, Cambridge Univ. Press, 1989.
5 Taylor R.J., The Stars- their Structure and Evolution, Cambridge Univ. Press,1994.
6 Abhyankar K.D., Stars and Galaxies, Universities Press, 2001.
7 Taylor R.J., Galaxies: Their Structure and Evolution, Cambridge Univ. Press, 1993
8 Jones M. H. and Lambourne R. J.(Editors), An Introduction to Galaxies and Cosmology, Cambridge University Press, 1998.
9 Padmanabhan T., An Invitation to Astrophysics, World Scientific, 2006.
10 Elements of Space Physics, R P Singhal, PHI, 2009
11 The solar Chromosphere and Corona , R Grant Athay, D Reidel publishing, 1976
12 Electrodynamics of Particles and Plasmas, Clemmow and Dougherty, Addison Wesley, 1969.

SECOND YEAR - SEMESTER – IV

Course Title	**Angular Momentum and Density matrix theory**							
Course Type	Soft Core- Theory		Total Hours	32	Hours/Week	02	Credits	02
Course Code	**D0330**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100
			External	Duration	C3	03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will understand:
CO-1	the concepts of angular momentum in quantum physics.
CO-2	the fundamentals of density matrix theory and its uses in optics.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	apply angular momentum algebra, angular momentum states and vector spherical harmonics.	PSO-2 PSO-5	Apply
CLO-2	outline the basics of Density matrix theory.	PSO-2 PSO-5	Analyze

Unit 1 Angular momentum **16hrs**

1.1 Commutation relations and states
1.2 Transformations under rotations
1.3 Coupling of three and four angular momenta
1.4 Racah coefficients, Wigner g- j symbols, applications
1.5 Spherical tensors
1.6 Wigner-Eckart theorem. Projection theorem. Evaluation of matrix elements between coupled angular momentum states.
1.7 Vector spherical harmonics. Gradient theorem (Proof not required). Multipole radiation

Keywords: angular momentum

Unit 2 Density matrix theory **16hrs**

2.1 Pure and mixed States, Density matrix and average expectation values
2.2 Equation of motion. Spin density matrix. Spin in external magnetic field, Larmor's precession, resonance effects and Rabi oscillations
2.3 2.4 Spherical tensor parameters and polarization
2.4 Transformation properties under rotations
2.5 Oriented, non-oriented and aligned systems
2.6 Polarization in scattering of spin 1/2 particles, scattering amplitude, asymmetry, double scattering experiments

Keywords: states, density matrix

Unit 3 Quantum field theory **16hrs**

3.1 Dirac Equation in covariant form, minimal coupling, bilinear covariants
3.2 Lagrangean formulation for fields, equal-time commutator.
3.3 Quantization of Dirac field. Maxwell and Dirac fields in interaction, interaction representation, S-matrix in Dyson's form
3.4 Feynman diagrams and rules for quantum electrodynamics
3.5 Density of states, method of summing and averaging over spins and polarizations

Keywords: fields

References:

1 J J Sakurai, S F Tuan (Editor), Modern Quantum Mechanics, Addison Wesley, India, 1990
2 J J Sakurai, Advanced Quantum Mechanics, Addison Wesley,1999
3 A R Edmonds, Angular momentum in quantum mechanics, Princeton University Press, 1996
4 L C Biedenharn and D Van Dam, Quantum theory of angular momentum, Academic Press Inc, 1966
5 M E Rose, Elementary theory of angular momentum, DOVER SCIENCE, 1957
7 K. Blum, Density matrix theory and applications, Plenum Press,1981
8 Akhiezer and Berestetsky, Quantum Electrodynamics, Interscience Publishers; Revised Edition edition, 1965

SECOND YEAR - SEMESTER – IV

Course Title	Condensed Matter Physics - 2								
Course Type	Soft Core- Theory		Total Hours	48	Hours/Week		03	Credits	03
Course Code	D0340	Evaluation	Internal	C1+C2 = 15+15				30 Marks	100
			External	Duration	C3		03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	Understand magnetic resonance techniques, defects and diffusion in solids, elastic constants of crystals, and optical properties of solids so as to lay a strong foundation in understanding the diverse properties of condensed state.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	define aspects of crystal structure including lattice shapes and the 3-dimensional symmetry associated with specific space group elements.	PSO-1	Understand
CLO-2	describe a series of diffraction experiments suitable for crystals, powders and other sample types, including the benefits of various radiation sources.	PSO-1 PSO-2	Understand
CLO-3	describe the magnetic and optical properties quantitatively.	PSO-1 PSO-2	Understand

Course Outline

UNIT-I Crystal Geometry II — 16hrs

1.1 X-ray crystallography

1.1.1 Reciprocal lattice, Ewald's construction, scattering by an electron and atom

1.1.2 Expressions for atomic scattering factor and structure factor, significance of Fourier analysis, absence reflections and space groups

1.1.3 Structure analysis by single crystal X-ray diffraction - intensity data collection, cell parameters and space group determination, intensity data corrections, phase determination (direct methods), refinement (cyclic Fourier refinement), determination of molecular and crystal structure (qualitative discussion) [Ref.1]

1.2 Defects in solids

1.2.1 Different types of defects, expression for concentration of vacancies, Frenkel and Schottky defects

1.2.2 Dislocations - Burger's Vector and Burger's circuit, expression for strain energy in the case of edge and screw dislocations [Ref.2]

1.3 Diffusion in solids

1.3.1 Fick's laws, diffusion in metals, Kirkendall effect, diffusion of interstitials, diffusion and ionic conductivity in alkali halides [Ref.2]

Keywords: crystals, defects

UNIT-2 Superconductors, elastic and optical properties of solids — 16hrs

2.1 Elastic constants of crystals

2.1.1 Definition of elastic strains and stresses in a solid, elastic compliance and stiffness constants, applications to cubic crystals and isotropic solids, elastic waves and experimental determination of elastic constants [Ref.3]

2.2 Superconductivity

2.2.1 BCS theory - elementary ideas, explanation of formation of Cooper pairs (Gedanken thought experiment), energy gap

2.2.2 Meissner effect and flux quantization. Josephson tunnelling, Josephson junction - theory for DC and AC bias. High T_c superconductors applications [Ref.4]

2.3 Optical properties of solids

2.3.1 Luminescence - general remarks, excitation and emission, Franck-Condon principle

2.3.2 Decay mechanisms - temperature dependent and independent decays

2.3.3 Thermo-luminescenceand glow curve, Gudden-Pohl effect. [Ref.5] , Colour centers – generation and types of colour centers [Ref.2]

Keywords: elasticity, superconductivity, luminescence

UNIT-3 Magnetism and magnetic resonances — 16hrs

3.1 Magnetic properties

3.1.1 Definition of magnetisation and susceptibility, Hund's rule, calculation of L, S and J for 3d and 4f shells

3.1.2 Setting up of Hamiltonian for an atom in an external magnetic field, explanation of diamagnetism

3.1.3 Van Vleck paramagnetism and quantum theory of paramagnetism using the above Hamiltonian in solids spin Hamiltonian and Heisenberg model [Ref.6]

3.2 Spin waves

3.2.1 Magnons,magnon dispersion relation for ferromagnets and antiferromagnets, Bloch's $T^{3/2}$ law [Ref.6]

3.3 Magnetic resonance

3.3.1 Phenomenological description, relaxation mechanisms, derivation of Casimir-Durpe relation

3.3.2 Nuclear magnetic moments, condition for resonance absorption, setting up of Bloch's equations, obtaining solutions for the steady state case and that of the weak RF field, expression for power absorption, change of inductance near resonance, dipolar line width in a rigid lattice [Ref.5]

Keywords: magnetic properties, spin waves

References

1 Sherwood D., Crystals, X-rays and Proteins, Longman, UK, 1976.
2 Wahab M.A., Solid State Physics, Narosa Publishing House, New Delhi, 1999.
3 Kittel C., Introduction to Solid State Physics, 7thEdn.John Wiley, New York, 1996.
4 Ibach H. and Luth H., Solid State Physics, Narosa Publishing House,, New Delhi, 1996.
5 Dekker A.J., Solid State Physics, Macmillan India Ltd., New Delhi, 2008.
6 Ashcroft N.W. and Mermin N.D., Solid State Physics, Saunders College Publishing, 1996.
7 Pillai S.O., Solid State Physics, New Age International Publications, 2006.

SECOND YEAR - SEMESTER – IV

Course Title	Condensed Matter Physics 3								
Course Type	Soft Core- Theory		Total Hours	48	Hours/Week		03	Credits	03
Course Code	**D0350**	Evaluation	Internal	C1+C2 = 15+15				30 Marks	100
			External	Duration	C3		03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	understand the theories of dielectrics and ferroelectrics; various facets related to synthesis, characterization and study of diverse properties and applications of nanomaterials and thin films so that they can understand the new developments in these emerging fields.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	describe different dielectric and ferroelectric properties.	PSO-1	Understand
CLO-2	analyse different properties of nanomaterial and their methods of preparation.	PSO-1 PSO-2	Analyze

Course Outline

UNIT-1 Dielectrics and Ferroelectrics **16hrs**

1.1 Dielectric properties of solids

1.1.1 Macroscopic description of static dielectric constant, the static electronic and ionic polarizabilities of molecules, orientation polarization, the static dielectric constant of gases, local electric field at an atom.

1.1.2 Lorentz field, field of dipoles inside cavity. Clausius-Mossotti relation. The complex dielectric constant and dielectric losses, dielectric losses and Debye relaxation time.

1.1.3 Classical theory of electronic polarization and optical absorption. [Ref.1,2].

1.2 Ferroelectricity

1.2.1 Basic properties of ferroelectric materials, classification and properties of ferroelectrics, dipole theory of ferroelectricity, objections against the dipole theory.

1.2.2 Ionic displacements and behavior of barium titanate above the curie temperature, theory of spontaneous polarization of barium titanate, thermodynamics of ferroelectric transitions, ferroelectric domains. [Ref.1-3].

Keywords: dielectrics, ferroelectricity

UNIT-2 Nanomaterials **16hrs**

2.1 Nanoparticles

2.1.1 Introduction to nanoscale materials and material systems

2.1.2 Properties of nanostructured materials – electronic, optical, mechanical, thermal, and chemical properties. [Ref.4-7].

2.2 Preparation of nanoparticles

2.2.1 Physical methods - laser ablation, sputtering, MBE

2.2.2 Chemical methods - precipitation, hydrothermal, solvothermal, chemical vapour deposition, sol-gel process

2.2.3 Lithographic techniques - AFM based nanolithography, e-beam, ion beam and, X-ray based lithography

2.2.4 Synthesis of nanoparticles involving biological substances. [Ref.4-7].
2.3 Characterization techniques
2.3.1 Microscopes - optical, SEM, TEM, STM, AFM
2.3.2 Diffraction techniques - XRD, EXAFS, neutron diffraction
2.3.3 Spectroscopes - UV-visible-IR absorption, FTIR, photoluminescence. [Ref.4-7].
2.4 Applications
2.4.1 Semiconductor electronics, sensors, actuators
2.4.2 Biomedical and environmental applications (qualitative). [Ref.4-7].

Keywords: nanomaterial, lithography

UNIT-3 Thin films **16hrs**

3.1 Preparation techniques
3.1.1 Physical vapour deposition methods, thermal evaporation - resistive heating, electron beam, laser
3.1.2 Sputtering deposition – DC (diode), RF and magnetron sputtering
3.1.2 Chemical vapour deposition – types of CVD, low pressure CVD (LPCVD) and plasma enhanced CVD (PECVD), metal organic CVD (MOCVD)
3.1.4 Chemical methods - electro deposition, electroless deposition and spray pyrolysis [Ref.10,11]
3.2 Characterization techniques
3.2.1 Thickness measurements - electrical methods (resistivity and capacitance measurements), optical methods (optical absorption and interference), mechanical methods (quartz crystal monitor)
3.2.2 Crystal structure: diffraction technique – X-ray diffraction
3.2.3 Chemical analysis: energy dispersive X-ray analysis (EDAX), X-ray photoelectron spectroscopy (XPS, ESCA) [Ref.8,9]
3.3 Applications
3.3.1 Solar cells, decorative coating, hard coatings, anti-reflection coating (qualitative) [Ref.8,9]

Keywords: thin films

References

1 Wahab M.A., Solid State Physics, Narosa Publishing House, New Delhi, 1999.
2 Pillai S.O., Solid State Physics, New Age International Publications, 2006.
3 Dekker A.J., Solid State Physics, Macmillan India Ltd., New Delhi, 2008.
4 Budinski K. G., Engineering Materials, 5thEdn. Prentice Hall India, 1996.
5 Callister W. D., Materials Science and Engineering - An Introduction, 4thEdn. John-Wiley, 1997.
6 Kulkarni S. K., Nanotechnology: Principles and Practices, Capital Publ. Co., New Delhi, 2007.
7 Rao C.N.R., John Thomas P. and Kulkarni G.U., Nanocrystals: Synthesis, Properties and Applications, Springer series in Materials Science 95, Springer-Verlag, Berlin, Heidelburg, 2007.
8 Hass G. and Thun R. E., Physics of Thin Films, Vol. IV, Academic Press, London, 1967.
9 Chopra K. L., Thin Film Phenomena, Robert E K Publishing Company, 1979.

SECOND YEAR - SEMESTER – IV

Course Title	**Condensed Matter Physics Lab 2**							
Course Type	Soft Core- Practical		Total Hours	128	Hours/Week	08	Credits	04
Course	**DP320**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100

Code			External	C3	Duration	03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	understand the practical aspects of Condensed Matter Physics and gain practical experience.
CO-2	understand advanced level experiments from areas such as semiconductor physics, X-ray crystallography, and magnetic properties of solids, dielectrics, ferroelectrics and nanoparticles.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	analyse the given x-ray diffraction data.	PSO-3	Analyze
CLO-2	perform different Solid State Physics experiments using semi-conductors.	PSO-3	Evaluate

Course Outline

Any eight of the following experiments:

1 Temperature variation of the reverse saturation current in a p-n junction diode.
2 Depletion capacitance of a p-n junction diode.
3 Determination of the energy gap of semiconductors by four-probe method.
4 Calculation of structure factors from powder X-ray diffraction data.
5 Calculation of relative integrated intensities from powder X-ray diffraction data.
6 Paramagnetic susceptibility by Gouy balance method.
7 Determination of Curie temperature of a magnetic material.
8 Curie temperature of a ferroelectric material.
9 Dielectric constant and its temperature variation.
10 Synthesis of nanoparticles

.

SECOND YEAR - SEMESTER – IV

Course Title	**Nuclear Physics 2**								
Course Type	Soft Core- Theory		Total Hours	48	Hours/Week		03	Credits	03
Course Code	**D0360**	Evaluation	Internal	C1+C2 = 15+15				30 Marks	100
			External	Duration	C3	03Hrs		70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	to understand the theories of various nuclear models.
CO-2	The concepts of nuclear reactor theory.
CO-3	The criticallity of reactors and transport equations.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs)** **On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	understand the importance of models in describing the properties of nuclei and nuclear interactions.	PSO-1 PSO-4	Understand
CLO-2	understand controlled fission reaction in various types of reactors.	PSO-2 PSO-4	Understand
CLO-3	analyse different properties of nanomaterial and their methods of preparation.	PSO-2 PSO-4	Understand

Course Outline

UNIT-1 Nuclear Decay — 16hrs

1.1 Beta decay

1.1.1 Classification of beta interactions, matrix elements

1.1.2 Fermi and Gamow-Teller selection rules for allowed beta decay, the non-conservation of parity in beta decay

1.1.3 Wu etal. Experiment.

1.1.4 The universal Fermi interaction. [Ref.3,4]

1.2 Gamma decay

1.2.1 Electromagnetic interactions with nuclei.

1.2.2 Multipole transitions, transition probabilities in nuclear matter

1.2.3 Weisskopf’s estimates, structure effects, selection rules,

1.2.4 Internal conversion, photodisintegration of deuteron and radiative capture of neutron by proton. [Ref.4,5]

Keywords: beta decay, gamma decay

UNIT-2 Nuclear Fission — 16hrs

2.1.0 Nuclear fission, mass-energy distribution of fission fragments, statistical model of fission [Ref.1]

2.2 Reactor theory-1

2.2.1 Neutron and its interaction with matter collision kinematics

2.2.2 Differential elastic scattering cross sections, isotropic scattering

2.2.3 The criticality condition for a reactor

2.2.4 Neutron transport equation using elementary diffusion theory

2.2.5 One group critical equation

2.2.6 The critical size on the basis of Fermi age theory [Ref.1]

Keywords: fission, reactors

UNIT-3 Reactor Theory-2 **16hrs**

3.1 Reactors - one group theory, spherical and cylindrical homogeneous reactor
3.2 The effective multiplication factor
3.3 Reflector reactors - effects of reflector, one group method of a homogeneous reactor with reflector, reflector savings
3.4 Infinite multiplication factor, critical size and critical mass
3.5 Heterogeneous reactor system - calculation of thermal utilization factor
3.6 Fast breeder reactor, evaluation of buckling using one group model [Ref.2]

Keywords: reactors, neutron number

References

1. Glasstone S. and Edlund M.C., Elements of Nuclear Reactor Theory, D. Van Nostrand Co., USA, 9th print, 1963.
2. Garg S., Ahmed F. and Kothari I.S., Physics of Nuclear Reactors, Tata McGraw-Hill, New Delhi, 1986.
3. Roy R.R. and Nigam B.P., Nuclear Physics, New Age International, New Delhi, 1986.
4. Hans H.S., Nuclear Physics - Experimental and Theoretical, New Age International Publishers, 2001.
5. Ghoshal S.N., Nuclear Physics, Vol. 2., S. Chand and Company, Delhi, 1994.

SECOND YEAR - SEMESTER – IV

Course Title	**Nuclear Physics 3**								
Course Type	Soft Core- Theory		Total Hours	48	Hours/Week		03	Credits	03
Course Code	**D0370**	Evaluation	Internal	C1+C2 = 15+15				30 Marks	100
			External	Duration	C3	03Hrs		70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	the n-p, p-p, pion-nucleon, scattering theory.
CO-2	various nuclear reaction and theories associated with them.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs)** **On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	understand the nuclear scattering theories.	PSO-2 PSO-4	Understand
CLO-2	understand the importance various nuclear reactions.	PSO-2 PSO-4	Understand

Course Outline

UNIT-1 Two particle systems and Scattering theory — 16hrs

1.1 Deuteron

1.1.1 Schrödinger equation for a two nucleon system, theory of the ground state of the deuteron under central and non-central forces, excited states of the deuteron, Rarita-Schwinger relations, deuteron magnetic and quadrupole moments. [Ref.1]

1.2 Nucleon-nucleon scattering processes

1.2.1 Theory of s-wave scattering of neutrons by free protons and experimental results

1.2.2 Wigner's formula for n-p scattering

1.2.3 Theory of scattering of slow neutrons by bound protons (ortho and para hydrogen) and experimental results

1.2.4 Effective range theory for n- p scattering

1.2.5 s-wave theory of proton-proton scattering

1.2.6 Mott's modification of Rutherford's formula, pion-nucleon scattering experimental results, (3/2,3/2) resonance [Ref.1,2]

Keywords: deuteron, np scattering

UNIT-2 Nuclear Reactions — 16hrs

2.1 Nuclear reactions-1

2.1.1 Plane wave theory of direct reactions

2.1.2 Born approximation-(plane wave)- Butler's theory

2.1.3 Cross section for nuclear scattering and reactions, shadow scattering

2.1.4 Breit-Wigner resonance formulae [Ref.3]

2.2 Nuclear reactions-2

2.2.1 Bohr's independence hypothesis, the compound nucleus (CN) reactions, decay rates of CN

2.2.2 Statistical theory of nuclear reactions, evaporation probability and cross sections for specific reactions [Ref.3]

Keywords: nuclear reactions

UNIT-3 Optical Model and Heavy Ion Physics — 16hrs

3.1 Optical model

3.1.1 Giant resonances, Kapur-Pearls' dispersion formula for potential scattering

3.1.2 Direct reactions - kinematics of stripping and pickup reactions, theory of stripping and pickup reactions

3.1.3 Inverse reactions [Ref.4]

3.2 Heavy ion physics

3.2.1 Special features of heavy ion physics, remote heavy ion electromagnetic interactions, Coulomb excitations, close encounters, heavy ion scattering, grazing interactions, particle transfer, direct and head on collisions, compound nucleus and quasi molecule formation [Ref.5]

Keywords: optical model, heavy ions

References

1. Roy R.R. and Nigam B.P., Nuclear Physics -Theory and Experiment, New Age International Ltd., New Delhi, 1986.
2. Hans H.S., Nuclear Physics-Experimental and Theoretical, New Age International Publishers, 2001.
3. Sachtler G.R., Nuclear Reactions, Addison Wesley, New York, 1983.
4. Mermier P. and Sheldon E., Physics of Nuclei and Particles, Vol. 2, Academic Press, USA, 1971.
5. Jackson D.F., Nuclear Reactions, Chapman and Hall, London, 1975.

SECOND YEAR - SEMESTER – III

Course Title	Nuclear Physics Lab 2								
Course Type	Soft Core- Practical		Total Hours	64	Hours/Week	04	Credits	02	
Course Code	**DP330**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100	
			External	C3	Duration	03Hrs	70 Marks		

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	carrying out precise measurements and handling sensitive equipments in nuclear physics.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	analyse beta spectrum, Bremsstrahlung radiation , and end point energy using different detectors.	PSO-3 PSO-4	Analyze
CLO-2	perform experiments using coincidence circuits.	PSO-5	Create

Course Outline

Experiments:

1 Variable delay line.
2 Pulse recorder.
3 Internal conversion using MCA.
4 Feather analysis: End-point energy of beta rays measurement.
5 Z dependence of external Bremsstrahlung radiation.
6 Fermi-Kurie plot: Determination of the end-point energy of beta rays using a plastic scintillationdetector.
7 Determination of source strength by gamma-gamma coincidence.
8 Determination of source strength by beta-gamma coincidence.

FIRST YEAR - SEMESTER – II

Course Title	Nanoscience and Nanotechnology								
Course Type	Open Elective - Theory		Total Hours	64	Hours/Week		04	Credits	04
Course Code	**B8140**	Evaluation	Internal	C1+C2 = 15+15				30 Marks	100
			External	Duration	C3	03Hrs		70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	understand fundamentals of nanoscience.
CO-2	understand the properties and applications of nanomaterials.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	describe nanostructured materials, their properties and applications.	PSO-1 PSO-2	Understand
CLO-2	synthesize and characterize nanostructured materials.	PSO-1 PSO-2	Understand

Course Outline
(Paper to be offered to Non-Physics Postgraduate Students)

UNIT-1 Fundamental concepts 16hrs

1.1 Introduction

1.1.1 The nanoscale, origin of nanotechnology, nanomaterials, quantum confinement, surface to volume ratio

1.1.2 Types of nanomaterials - fullerenes, nanowires, nanotubes, thin films

1.1.3 Types of nanoparticles -metals, semiconductors, graphene, carbon nano tubes, etc. [Ref.1,2]

1.2 Synthesis of nanomaterials

1.2.1 Physical methods: mechanical - ball milling, melt mixing

1.2.2 Evaporation - ion sputtering, laser ablation, laser pyrolysis, chemical vapour deposition, molecular beam epitaxy

1.2.3 Chemical methods - colloidal synthesis and capping of nanoparticles. [Ref.1,2].

Keywords: nanomaterial, synthesis of nanomaterials

UNIT-2 Characterization Techniques 16hrs

2.1 Microscopes: optical, SEM, TEM, STM, AFM

2.2 Diffraction techniques: XRD, EXAFS, neutron diffraction

2.3 Spectroscopes: UV-visible-IR absorption, FTIR, photoluminescence [Ref.1,2]

Keywords: characterization

UNIT-3 Properties of Nanomaterials 16hrs

3.1 Mechanical properties

3.2 Electrical - classification into metals, semiconductors and insulators, band structures, mobility, resistivity, Hall effect, magnetoresistance

3.3 Optical - optical absorption and transmission, photoluminescence, electro-luminescence, thermoluminescence

3.4 Magnetic – magnetism, types of magnetic materials - dia-, para-, ferro-, antiferro- and nano-magnetism [Ref.1,2]

Keywords: properties of nanomaterials

UNIT-4 Nanotechnology 16hrs

4.1 Applications of nanoscience and nanotechnology,introduction to societal implications of nanoscience and nanotechnology

4.2 Nanotechnology goals - knowledge and scientific understanding of nature, industrial manufacturing, materials and products, medicine and the human body

4.3 Sustainability - agriculture, water, energy, materials and clean environment, space exploration, national security, moving into the market [Ref.5-7]

Keywords: nanotechnology

References

1 Kulkarni S. K., Nanotechnology: Principles and Practices, Capital Publ. Co., New Delhi, 2007.

2 Rao C.N.R., John Thomas P. and Kulkarni G.U., Nanocrystals: Synthesis, Properties and Applications, Springer series in Materials Science 95, Springer-Verlag, Berlin, Heidelburg, 2007.

3 Pradeep T., Nano: The Essentials: Understanding Nanoscience and Nanotecnology, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.

4 Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, Nanoscale Science and Technology, John Wiley and Sons, Ltd., UK, 2005.

5 Concept Document "Nanoscience& Technology Initiative" of DST, GOI, New Delhi, 2002.

6 Winner, Langdon, "Societal Implications of Nanotechnology", Testimony to the Committee on Science of the US House of Representatives, 2003.

7 Nanotechnology Regulation and Policy Worldwide (Artech House), Jeffrey H. Matsuura, 2006.

SECOND YEAR - SEMESTER – II

Course Title	Environmental Physics							
Course Type	Open Elective - Theory		Total Hours	64	Hours/Week	04	Credits	04
Course Code	**C9150**	Evaluation	Internal	C1+C2 = 15+15			30 Marks	100
			External	Duration	C3	03Hrs	70 Marks	

COURSE OBJECTIVES (COs)

CO No.	On completion of the course the student will be able to:
CO-1	acquire necessary fundamental knowledge required to describe various environmental processes.
CO-2	understand the basic in our environment.

Mapping of CLOs with PSOs &CDLs			
CLOs No.	**Course Learning Outcomes (CLOs) On completion of the course the student will learn to :**	**PSOs Addressed**	**CLDs**
CLO-1	understand how to apply the basic thermodynamics to the human environment.	PSO-1 PSO-2	Understand
CLO-2	understand the basic composition, structure and dynamics of the atmosphere.	PSO-1 PSO-2	Understand
CLO-3	discuss specific environmental problems such as ozone depletion and global warming in the context of an overall understanding of the dynamics of the atmosphere.	PSO-1 PSO-2	Understand
CLO-4	discuss the problems of energy demand and explain the possible contributions of renewable to energy supply.	PSO-1 PSO-2	Understand

Course Outline
(Paper to be offered to Non-Physics Postgraduate Students)

Unit 1 Introduction to environmental physics **16hrs**

1 The human environment

1.1 Laws of thermodynamics: First, Second and Third law Third law

1.2 **Laws of thermodynamics and the human body**

1.2.1 Energy and metabolism

1.2.2 First law and Second law of thermodynamics and the human body

1.3 **Energy transfers**

1.3.1 Conduction

1.3.2 Convection , Newton's law of cooling

1.3.3 Radiation, Evaporation

1.4 Survival in cold and hot climates.

Keywords: thermodynamics, energy

Unit 2 Atmosphere and radiation **16hrs**

2.1 Structure and composition of the atmosphere

2.1.1 Residence time

2.1.2 Photochemical pollution

2.1.3 Atmospheric aerosols

2.2 Atmospheric pressure

2.3 Ozone : Ozone hole, Ozone in polar region

2.4 Terrestrial radiation

2.5 Earth as a black body
2.6 Greenhouse effect, Greenhouse gases, Global warming

Keywords: radiation

Unit 3 Water, Wind and Physics of soil **16hrs**

3.1 Physics of Water
3.1.1 Hydrosphere, Hydrologic cycle
3.1.2 Water in the atmosphere
3.1.3 Clouds, Physics of cloud formation
3.1.4 Growing droplets in cloud
3.1.5 Thunderstorms

3.2 Physics of Wind
3.2.1 Measuring the wind, Physics of wind creation
6.2.1 Principal forces acting on air masses: Gravitational force, pressure gradient, Coriolis inertial force, frictional force
3.3 Cyclones and anticyclones
3.4 Global convection
3.5 Global wind patterns

3.6 Soil physics
3.6.1 Soils
3.6.2 Soil and hydrologic cycle
3.6.3 Surface tension and soils, Water flow
3.6.4 Water evaporation, Soil temperature

Keywords: wind, water, soil

Unit 4 Energy **16hrs**

4.1 Introduction : World energy demand and supplies
4.2 Fossil fuels
4.3 Nuclear power : Nuclear fission, Nuclear reactors, Nuclear fusion
4.4 **Renewable energy**
4.4.1 Solar energy : Transferring solar energy, Solar photovoltaic electricity
4.4.2 Wind power : Average power of a moving mass of fluid
4.4.3 Hydroelectric power
4.4.4 Water moving through a cylindrical tube
4.4.5 Ocean energy: Tidal power, wave energy
4.4.6 Biomass and bio-fuels
4.4.7 Geothermal power

Keywords: renewable energy

References

1 Nigel Mason and Peter Hughes,Introduction to Environmental Physics: Planet Earth, Life and Climate, Taylor and Francis, 2001.
2 John Monteith And Mike Unsworth, Principles Of Environmental Physics, Academic Press 3rd Edition , 2007