ANNAMALAI UNIVERSITY

(Accredited with ‘A’ Grade by NAAC)

M.Sc. PHYSICS (TWO YEAR PROGRAMME)

Regulations & Curriculum-2019

ANNAMALAI UNIVERSITY

REGULATIONS FOR THE TWO-YEAR POST GRADUATE PROGRAMMES UNDER CHOICE BASED CREDIT SYSTEM (CBCS)

These Regulations are common to all the students admitted to the Two-Year Master's Programmes in the Faculties of Arts, Science, Indian Languages, Education, Marine Sciences, and Fine Arts from the academic year 2019-2020 onwards.

1. Definitions and Nomenclature

1.1 University *refers to Annamalai University.*

1.2 Department *means any of the academic departments and academic centres at the University.*

1.3 Discipline *refers to the specialization or branch of knowledge taught and researched in higher education. For example, Botany is a discipline in the Natural Sciences, while Economics is a discipline in Social Sciences.*

1.4 Programme *encompasses the combination of courses and/or requirements leading to a Degree. For example, M.A., M.Sc.*

1.5 Course *is an individual subject in a programme. Each course may consist of Lectures/Tutorials/Laboratory work/Seminar/Project work/Experiential learning/ Report writing/viva-voce etc. Each course has a course title and is identified by a course code.*

1.6 Curriculum *encompasses the totality of student experiences that occur during the educational process.*

1.7 Syllabus *is an academic document that contains the complete information about an academic programme and defines responsibilities and outcomes. This includes course information, course objectives, policies, evaluation, grading, learning resources and course calendar.*

1.8 Academic Year *refers to the annual period of sessions of the University that comprises two consecutive semesters.*

1.9 Semester *is a half-year term that lasts for a minimum duration of 90 days. Each academic year is divided into two semesters.*

1.10 Choice Based Credit System *A mode of learning in higher education that enables a student to have the freedom to select his/her own choice of elective courses across various disciplines for completing the Degree programme.*

1.11 Core Course *is mandatory and an essential requirement to qualify for the Degree.*

1.12 Elective Course *is a course that a student can choose from a range of alternatives.*

1.13 Value-added Courses *are optional courses that complement the students' knowledge and skills and enhance their employability.*

1.14 Credit *refers to the quantum of course work in terms of number of class hours in a semester required for a programme. The credit value reflects the content and duration of a particular course in the curriculum.*

1.15 Credit Hour *refers to the number of class hours per week required for a course in a semester. It is used to calculate the credit value of a particular course.*

1.16 Programme Outcomes (POs) *are statements that describe crucial and essential knowledge, skills and attitudes that students are expected to achieve and can reliably manifest at the end of a programme.*

1.17 ***Programme Specific Outcomes (PSOs)*** *are statements that list what the graduate of a specific programme should be able to do at the end of the programme.*

1.18 ***Learning Objectives also known as Course Objectives*** *are statements that define the expected goal of a course in terms of demonstrable skills or knowledge that will be acquired by a student as a result of instruction.*

1.19 ***Course Outcomes (COs)*** *are statements that describe what students should be able to achieve/demonstrate at the end of a course. They allow follow-up and measurement of learning objectives.*

1.20 ***Grade Point Average (GPA)*** *is the average of the grades acquired in various courses that a student has taken in a semester. The formula for computing GPA is given in section 11.3*

1.21 ***Cumulative Grade Point Average (CGPA)*** *is a measure of overall cumulative performance of a student over all the semesters. The CGPA is the ratio of total credit points secured by a student in various courses in all semesters and the sum of the total credits of all courses in all the semesters.*

1.22 ***Letter Grade*** *is an index of the performance of a student in a particular course. Grades are denoted by the letters S, A, B, C, D, E, RA, and W.*

2. Programme Offered and Eligibility Criteria

Faculty of Science	
M.Sc. Physics	*A pass in B.Sc. Physics as major subject and Mathematics and Chemistry as ancillary subjects from any University with not less than 50% of marks in Part–III.*

2.1 In the case of SC/ST and Differently-abled candidates, a pass is the minimum qualification for the above Programme.

3. Reservation Policy

Admission to the programme will be strictly based on the reservation policy of the Government of Tamil Nadu.

4. Programme Duration

4.1 *The Two Year Master's Programme consists of two academic years.*

4.2 *Each academic year is divided into two semesters, the first being from July to November and the second from December to April.*

4.3 *Each semester will have 90 working days (18 weeks).*

5 Programme Structure

5.1 *The Two Year Master's Programme consists of Core Courses, Elective Courses (Departmental & Interdepartmental), and Project.*

5.2 Core courses

5.2.1. *These are a set of compulsory courses essential for each programme.*

5.2.2. *The core courses include both Theory (Core Theory) and Practical (Core Practical) courses.*

5.3. Elective courses

5.3.1 Departmental Electives (DEs) *are the Electives that students can choose from a range of Electives offered within the Department.*

5.3.2 ***Interdepartmental Electives (IDEs)*** *are Electives that students can choose from amongst the courses offered by other departments of the same faculty as well as by the departments of other faculties.*

5.3.3 Students shall take a combination of both DEs and IDEs.

5.4. Experiential Learning

5.4.1. *Experiential learning provides opportunities to students to connect principles of the discipline with real-life situations.*

5.4.2. *In-plant training/field trips/internships/industrial visits (as applicable) fall under this category.*

5.4.3. *Experiential learning is categorised as Core.*

5.5. Project

5.5.1. *Each student shall undertake a Project in the final semester.*

5.5.2. *The Head of the Department shall assign a Research Supervisor to the student.*

5.5.3. *The Research Supervisor shall assign a topic for research and monitor the progress of the student periodically.*

5.5.4. *Students who wish to undertake project work in recognised institutions/industry shall obtain prior permission from the University. The Research Supervisor will be from the host institute, while the Co-Supervisor shall be a faculty in the parent department.*

5.6. Value added Courses (VACs)

5.6.1. *Students may also opt to take Value added Courses beyond the minimum credits required for award of the Degree. VACs are outside the normal credit paradigm.*

5.6.2. *These courses impart employable and life skills. VACs are listed in the University website and in the Handbook on Interdepartmental Electives and VACs.*

5.6.3. *Each VAC carries 2 credits with 30 hours of instruction, of which 60% (18 hours) shall be Theory and 40% (12 hours) Practical.*

5.6.4. *Classes for a VAC are conducted beyond the regular class hours and preferably in the II and III Semesters.*

5.7. Online Courses

5.7.1. *The Heads of Departments shall facilitate enrolment of students in Massive Open Online Courses (MOOCs) platform such as SWAYAM to provide academic flexibility and enhance the academic career of students.*

5.7.2. *Students who successfully complete a course in the MOOCs platform shall be exempted from one elective course of the programme.*

5.8. ***Credit Distribution***

The credit distribution is organized as follows:

Credit distribution	***Credits***
Core Courses	*65-75*
Elective Courses	*15*
Project	*6-8*
Total (Minimum requirement for award of Degree)	***90-95****

Each Department shall fix the minimum required credits for award of the Degree within the prescribed range of 90-95 credits.

5.9. ***Credit Assignment***

Each course is assigned credits and credit hours on the following basis:

1 Credit is defined as:

1 Lecture period of one hour per week over a semester

1 Tutorial period of one hour per week over a semester

1 Practical/Project period of two or three hours (depending on the discipline) per week over a semester.

6. Attendance

6.1 *Each faculty handling a course shall be responsible for the maintenance of Attendance and Assessment Record for candidates who have registered for the course.*

6.2 *The Record shall contain details of the students' attendance, marks obtained in the Continuous Internal Assessment (CIA) Tests, Assignments and Seminars. In addition the Record shall also contain the organisation of lesson plan of the Course Instructor.*

6.3 *The record shall be submitted to the Head of the Department once a month for monitoring the attendance and syllabus coverage.*

6.4 *At the end of the semester, the record shall be duly signed by the Course Instructor and the Head of the Department and placed in safe custody for any future verification.*

6.5 *The Course Instructor shall intimate to the Head of the Department at least seven calendar days before the last instruction day in the semester about the attendance particulars of all students.*

6.6 *Each student shall have a minimum of 75% attendance in all the courses of the particular semester failing which he or she will not be permitted to write the End-Semester Examination. The student has to redo the semester in the next year.*

6.7 *Relaxation of attendance requirement up to 10% may be granted for valid reasons such as illness, representing the University in extracurricular activities and participation in NCC/NSS/YRC/RRC.*

*7. **Mentor-Mentee System***

7.2. *To help the students in planning their course of study and for general advice on the academic programme, the Head of the Department will attach certain number of students to a member of the faculty who shall function as a Mentor throughout their period of study.*

7.3. *The Mentors will guide their mentees with the curriculum, monitor their progress, and provide intellectual and emotional support.*

7.4. *The Mentors shall also help their mentees to choose appropriate electives and value-added courses, apply for scholarships, undertake projects, prepare for competitive examinations such as NET/SET, GATE etc., attend campus interviews and participate in extracurricular activities.*

*8. **Examinations***

8.2. *The examination system of the University is designed to systematically test the student's progress in class, laboratory and field work through Continuous Internal Assessment (CIA) Tests and End-Semester Examination (ESE).*

8.3. *There will be two CIA Tests and one ESE in each semester.*

8.4. *The Question Papers will be framed to test different levels of learning based on Bloom's taxonomy viz. Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation/Creativity.*

8.5. Continuous Internal Assessment Tests

8.5.1. *The CIA Tests shall be a combination of a variety of tools such as class tests, assignments, seminars, and viva-voce that would be suitable to the course. This requires an element of openness.*

8.5.2. *The students are to be informed in advance about the assessment procedures.*

8.5.3. *The pattern of question paper will be decided by the respective faculty.*

8.5.4. *CIA Test-I will cover the syllabus of the first two units while CIA Test-II will cover the last three units.*

8.5.5. *CIA Tests will be for two to three hours duration depending on the quantum of syllabus.*

8.5.6. *A student cannot repeat the CIA Test-I and CIA Test-II. However, if for any valid reason, the student is unable to attend the test, the prerogative of arranging a special test lies with the teacher in consultation with the Head of the Department.*

8.6. End Semester Examinations (ESE)

8.6.1. *The ESE for the first/third semester will be conducted in November and for the second/fourth semester in May.*

8.6.2. *A candidate who does not pass the examination in any course(s) of the first, second and third semesters will be permitted to reappear in such course(s) that will be held in April and November in the subsequent semester/year.*

8.6.3. *The ESE will be of three hours duration and will cover the entire syllabus of the course.*

9. Evaluation

9.1. Marks Distribution

9.1.1. *Each course, Theory and Practical as well as Project/Internship/Field work/In-plant training shall be evaluated for a maximum of 100 marks.*

9.1.2. *For the theory courses, CIA Tests will carry 25% and the ESE 75% of the marks.*

9.1.3. *For the Practical courses, the CIA Tests will constitute 40% and the ESE 60% of the marks.*

9.2. Assessment of CIA Tests

9.2.1. *For the CIA Tests, the assessment will be done by the Course Instructor*

9.2.2. *For the Theory Courses, the break-up of marks shall be as follows:*

	Marks
Test-I & Test-II	15
Seminar	05
Assignment	05
Total	25

9.2.3. *For the Practical Courses (wherever applicable), the break-up of marks shall be as follows:*

	Marks
Test-I	15
Test-II	15
Viva-voce and Record	10
Total	40

9.3. Assessment of End-Semester Examinations

9.3.1. *Evaluation for the ESE is done by both External and Internal examiners (Double Evaluation).*

9.3.2. *In case of a discrepancy of more than 10% between the two examiners in awarding marks, third evaluation will be resorted to.*

9.4. Assessment of Project/Dissertation

9.4.1. *The Project Report/Dissertation shall be submitted as per the guidelines laid down by the University.*

9.4.2. *The Project Work/Dissertation shall carry a maximum of 100 marks.*

9.4.3. *CIA for Project will consist of a Review of literature survey, experimentation/field work, attendance etc.*

9.4.4. The Project Report evaluation and viva-voce will be conducted by a committee constituted by the Head of the Department.

9.4.5. The Project Evaluation Committee will comprise the Head of the Department, Project Supervisor, and a senior faculty.

9.4.6. The marks shall be distributed as follows:

Continuous Internal Assessment (25 Marks)		*End Semester Examination (75 Marks)*	
Review-I 10	*Review-II: 15*	*Project / Dissertation Evaluation*	*Viva-voce*
		50	*25*

9.5. Assessment of Value-added Courses

9.5.1. Assessment of VACs shall be internal.

9.5.2. Two CIA Tests shall be conducted during the semester by the Department(s) offering VAC.

9.5.3. A committee consisting of the Head of the Department, faculty handling the course and a senior faculty member shall monitor the evaluation process.

9.5.4. The grades obtained in VACs will not be included for calculating the GPA.

9.6. Passing Minimum

9.6.1. A student is declared to have passed in each course if he/she secures not less than 40% marks in the ESE and not less than 50% marks in aggregate taking CIA and ESE marks together.

9.6.2. A candidate who has not secured a minimum of 50% of marks in a course (CIA + ESE) shall reappear for the course in the next semester/year.

10. Conferment of the Master's Degree

A candidate who has secured a minimum of 50% marks in all courses prescribed in the programme and earned the minimum required credits shall be considered to have passed the Master's Programme.

11. Marks and Grading

11.1. The performance of students in each course is evaluated in terms Grade Point (GP).

11.2. The sum total performance in each semester is rated by Grade Point Average (GPA) while Cumulative Grade Point Average (CGPA) indicates the Average Grade Point obtained for all the courses completed from the first semester to the current semester.

11.3. The GPA is calculated by the formula

$$GPA = \frac{\sum_{i=1}^{n} C_i G_i}{\sum_{i=1}^{n} C_i}$$

where, C_i is the Credit earned for the Course i in any semester;

G_i is the Grade Point obtained by the student for the Course i and

n is the number of Courses passed in that semester.

*11.4. **CGPA** is the Weighted Average Grade Point of all the Courses passed starting from the first semester to the current semester.*

$$CGPA = \frac{\sum_{i=1}^{m} \sum_{i=1}^{n} C_i G_i}{\sum_{i=1}^{m} \sum_{i=1}^{n} C_i}$$

where, C_i is the Credit earned for the Course i in any semester;
G_i is the Grade Point obtained by the student for the Course i and
n is the number of Courses passed in that semester.
m is the number of semesters

11.5. *Evaluation of the performance of the student will be rated as shown in the Table.*

Letter Grade	***Grade Points***	***Marks %***
S	*10*	*90 and above*
A	*9*	*80-89*
B	*8*	*70-79*
C	*7*	*60-69*
D	*6*	*55-59*
E	*5*	*50-54*
RA	*0*	*Less than 50*
W	*0*	*Withdrawn from the examination*

11.6. Classification of Results. *The successful candidates are classified as follows:*

11.6.1. *For **First Class with Distinction:** Candidates who have passed all the courses prescribed in the Programme in the first attempt with a CGPA of 8.25 or above within the programme duration. Candidates who have withdrawn from the End Semester Examinations are still eligible for First Class with Distinction (See Section 12 for details).*

11.6.2. *For **First Class:** Candidates who have passed all the courses with a CGPA of 6.5 or above.*

11.6.3. *For **Second Class:** Candidates who have passed all the courses with a CGPA between 5.0 and less than 6.5.*

11.6.4. *Candidates who obtain highest marks in all examinations at the first appearance alone will be considered for University Rank.*

11.7. Course-Wise Letter Grades

11.7.1. *The percentage of marks obtained by a candidate in a course will be indicated in a letter grade.*

11.7.2. *A student is considered to have completed a course successfully and earned the credits if he/she secures an overall letter grade other than RA.*

11.7.3. *A course successfully completed cannot be repeated for the purpose of improving the Grade Point.*

11.7.4. *A letter grade RA indicates that the candidate shall reappear for that course. The RA Grade once awarded stays in the grade card of the student and is not deleted even when he/she completes the course successfully later. The grade acquired later by the student will be indicated in the grade sheet of the Odd/Even semester in which the candidate has appeared for clearance of the arrears.*

11.7.5. *If a student secures RA grade in the Project Work/Field Work/Practical Work/Dissertation, he/she shall improve it and resubmit if it involves only rewriting/ incorporating the clarifications suggested by the evaluators or he/she can re-register and carry out the same in the subsequent semesters for evaluation.*

12. *Provision for Withdrawal from the End Semester Examination*

12.1. *The letter grade W indicates that a candidate has withdrawn from the examination.*

12.2. *A candidate is permitted to withdraw from appearing in the ESE for one course or courses in* ***ANY ONE*** *of the semesters* ***ONLY*** *for exigencies deemed valid by the University authorities.*

12.3. ***Permission for withdrawal from the examination shall be granted only once during the entire duration of the programme.***

12.4. *Application for withdrawal shall be considered* ***only*** *if the student has registered for the course(s), and fulfilled the requirements for attendance and CIA tests.*

12.5. *The application for withdrawal shall be made ten days prior to the commencement of the examination and duly approved by the Controller of Examinations. Notwithstanding the mandatory prerequisite of ten days notice, due consideration will be given under extraordinary circumstances.*

12.6. *Withdrawal is* ***<u>not</u>*** *granted for arrear examinations of courses in previous semesters and for the final semester examinations.*

12.7. *Candidates who have been granted permission to withdraw from the examination shall reappear for the course(s) when the course(s) are offered next.*

12.8. *Withdrawal shall not be taken into account as an appearance for the examination when considering the eligibility of the candidate to qualify for First Class with Distinction.*

13. *Academic misconduct*

Any action that results in an unfair academic advantage/interference with the functioning of the academic community constitutes academic misconduct. This includes but is not limited to cheating, plagiarism, altering academic documents, fabrication/falsification of data, submitting the work of another student, interfering with other students' work, removing/defacing library or computer resources, stealing other students' notes/assignments, and electronically interfering with other students'/University's intellectual property. Since many of these acts may be committed unintentionally due to lack of awareness, students shall be sensitised on issues of academic integrity and ethics.

14. *Transitory Regulations*

Wherever there has been a change of syllabi, examinations based on the existing syllabus will be conducted for two consecutive years after implementation of the new syllabus in order to enable the students to clear the arrears. Beyond that, the students will have to take up their examinations in equivalent subjects, as per the new syllabus, on the recommendation of the Head of the Department concerned.

15. *Notwithstanding anything contained in the above pages as Rules and Regulations governing the Two Year Master's Programmes at Annamalai University, the Syndicate is vested with the powers to revise them from time to time on the recommendations of the Academic Council.*

M. Sc. PHYSICS (Two Year) Programme

PROGRAMME CODE: SPHY21

Programme Structure
(For students admitted from the academic year 2019 - 2020)

Course Code	Course Title	L	P	C	Inter. Mark	Exter. Mark	Total
FIRST SEMESTER							
19PHYC101	Core 1: Classical and Statistical Mechanics	4		4	25	75	100
19PHYC102	Core 2: Electronics	4		4	25	75	100
19PHYC103	Core 3: Mathematical Physics-I	4		4	25	75	100
19PHYP104	Core 4: Practical – I	-	**9**	**6**	40	60	100
	Elective 1: Interdepartmental Elective	3		3	25	75	100
	Total Credits			**21**			
SECOND SEMESTER							
19PHYC201	Core 5: Mathematical Physics - II	4		4	25	75	100
19PHYC202	Core 6: Condensed Matter Physics - I	4		4	25	75	100
19PHYC203	Core 7: Electromagnetic Theory	4		4	25	75	100
19PHYP204	Core 8: Practical - II	-	**9**	**6**	40	60	100
	Elective 2: Interdepartmental Elective	3		3	25	75	100
19PHYE205	Elective 3: Department Elective	3		3	25	75	100
	Total Credits			**24**			
THIRD SEMESTER							
19PHYC301	Core 9: Quantum Mechanics – I	4		4	25	75	100
19PHYC302	Core 10: Condensed Matter Physics - II	4		4	25	75	100
19PHYC303	Core 11: Nuclear and Elementary Particle Physics	4		4	25	75	100
19PHYP304	Core 12: Practical – III	-	**9**	**6**	40	60	100
	Elective 4: Interdepartmental Elective	3		3	25	75	100
19PHYE305	Elective 5: Department Elective	3		3	25	75	100
	Total Credits			**24**			
FOURTH SEMESTER							
19PHYC401	Core 13: Quantum Mechanics – II	4		4	25	75	100
19PHYC402	Core 14: Spectroscopy	4		4	25	75	100
19PHYC403	Core 15: Physics of Nanomaterials	4		4	25	75	100
19PHYP404	Core 16: Practical – IV	-	9	6	40	60	100
19PHYPJ405	Project (Dissertation)	-	9	6	25	50	100
	Viva-Voce				0	25	
	Total Credits			**24**			
TOTAL CREDITS				**93**			
1. **Value Added Courses** 2. **Online Courses (SWAYAM, MOOC's and NPTEL)**							

DEPARTMENT ELECTIVE (DE) COURSES

Course Code	Course Title	Hours /week		C	Marks		
		L	P		CIA	ESE	Total
Elective 3: Department Elective							
19PHYE205.1	Microprocessor and Microcontroller	3	-	3	25	75	100
19PHYE205.2	Physics of the Earth	3	-	3	25	75	100
19PHYE205.3	Energy Physics	3	-	3	25	75	100
Elective 5: Department Elective							
19PHYE305.1	Instrumentation	3	-	3	25	75	100
19PHYE305.2	Biomedical Instrumentation	3	-	3	25	75	100
19PHYE 305.3	Petrophysics	3	-	3	25	75	100
19PHYE305.4	Medical Physics	3	-	3	25	75	100
19PHYE305.5	Biophysics	3	-	3	25	75	100

L- Lectures; P- Practical; C- Credits; CIA- Continuous Internal Assessment; ESE- End-Semester Examination

Note:

1. **Students shall take both Department Electives (DEs) and Interdepartmental Electives (IDEs) from a range of choices available.**
2. **Students may opt for any Value-added Courses listed in the University website.**

PROGRAM OUTCOMES (POs):

By the end of the program, the students will be able to

PO1	**Domain knowledge**: Demonstrate knowledge of basic concepts, principles and applications of the specific science discipline.
PO2	**Resource Utilisation.** Cultivate the skills to acquire and use appropriate learning resources including library, e-learning resources, ICT tools to enhance knowledge-base and stay abreast of recent developments.
PO3	**Analytical and Technical Skills:** Ability to handle/use appropriate tools/techniques/equipment with an understanding of the standard operating procedures, safety aspects/limitations.
PO4	**Critical thinking and Problem solving:** Identify and critically analyse pertinent problems in the relevant discipline using appropriate tools and techniques as well as approaches to arrive at viable conclusions/solutions.
PO5	**Project Management**: Demonstrate knowledge and scientific understanding to identify research problems, design experiments, use appropriate methodologies, analyse and interpret data and provide solutions. Exhibit organisational skills and the ability to manage time and resources.
PO6	**Individual and team work**: Exhibit the potential to effectively accomplish tasks independently and as a member or leader in diverse teams, and in multidisciplinary settings.
PO7	**Effective Communication**: Communicate effectively in spoken and written form as well as through electronic media with the scientific community as well as with society at large. Demonstrate the ability to write dissertations, reports, make effective presentations and documentation.
PO8	**Environment and Society**: Analyse the impact of scientific and technological advances on the environment and society and the need for sustainable development.
PO9	**Ethics**: Commitment to professional ethics and responsibilities.
PO10	**Life-long learning:** Ability to engage in life-long learning in the context of the rapid developments in the discipline.

PROGRAM SPECIFIC OUTCOMES (PSOs):

By the end of the program, the students will be able to

PSO1	Understand principles of physics for the scientific phenomena in classical domain.
PSO2	Understand the mathematical techniques for describing in depth knowledge of physical concepts.
PSO3	Understand and apply statistical methods for describing the classical and quantum particles in various physical systems and processes.
PSO4	Understand and apply inter-disciplinary concepts and for understanding and describing the natural phenomena.
PSO5	Understand the principles of Quantum mechanics for knowing the physical systems in quantum arena.
PSO6	Provide exposure in various specializations of Physics (Solid State Physics/Nuclear Physics/Particle Physics).
PSO7	Provide exposure to modern experimental/theoretical methods for measurement, observation and fundamental understanding of physical phenomena/systems.
PSO8	Engage in research and life-long learning to adapt to changing environment.

MAPPING OF PROGRAMME SPECIFIC OUTCOMES WITH PROGRAMME OUTCOMES

By the end of the program, the students will be able to

Programme Specific Outcomes (PSOs)	Programme Outcomes (POs)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
PSO1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PSO2	✓	✓		✓						
PSO3	✓	✓								
PSO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
P5O5	✓	✓		✓			✓	✓	✓	✓
PSO6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PSO7	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PSO8	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

SEMESTER - I	19PHYC101 - CLASSICAL AND STATISTICAL MECHANICS	Credit:4 Hours:4

LEARNING OBJECTIVES:

- To develop familiarity with the physical concepts and facility with the mathematical methods of classical mechanics
- The main goal of this course is to acquire fundamental knowledge of classical and quantum statistical mechanics.
- Construct a bridge between macroscopic thermodynamics and microscopic statistical mechanics by using mathematical methods and fundamental physics for individual particles.

UNIT– 1: MECHANICS OF A PARTICLE AND SYSTEM OF PARTICLES

Mechanics of a Particle and System of particles – Constraints – Degrees of freedom – Generalized coordinates and its advantages – Hamilton’s variational principle – Lagrange’s equation of motion – D’Alembert’s principle – Applications of Lagrange’s equation of motion – Linear harmonic oscillator and simple pendulum. Cyclic co-ordinates – Equivalence of Lagrange’s and Newton’s equations – Principle of least action.

UNIT– 2: CANONICAL TRANSFORMATIONS

Canonical transformation and Conditions for transformation to be canonical with examples – Hamilton-Jacobi method. Hamilton’s principal function – Solution of harmonic oscillator problem by Hamilton-Jacobi method – Poisson brackets, Properties and Invariance of Poisson brackets, Equation of motion in Poisson bracket – Small oscillations – Normal modes and Normal Coordinates – Free vibrations of a linear triatomic molecule.

UNIT– 3: MAXWELL – BOLTZMANN STATISTICS

Postulates of kinetic theory of gases – Maxwell-Boltzmann distribution of velocities – Derivation of Maxwell – Boltzmann distribution equation – Significance of Maxwell-Boltzmann equation – Phase Space – Ensembles and their types – Liouville's theorem – Statement and Proof.

UNIT– 4: EQUIPARTITION OF ENERGY AND PARTITION FUNCTION

Principle of equipartition of energy – Partition function and their properties – Connection between the partition function and thermodynamic quantities – Mean values obtained from distribution law – Gibb's paradox – Explanation and proof for occurrence of paradox – Sackur – Tetrode equation and its significance.

UNIT– 5: QUANTUM STATISTICS

Differentiation of B-E and F-D particles – Derivations of B-E and F-D distributions – Comparison of M-B,B-E and F-D statistics – Black body radiation and the Planck radiation law – Derivation with explanation – Ideal Bose gas – Gas degeneracy – Derivation - Bose Einstein Condensation – Derivation with explanation (Example: Liquid Helium)

TEXT BOOKS:

1. R.G. Takwale and P.S.Puranik, Introduction to Classical Mechanics, Tata Mc Graw Hill, New Delhi,1979.
2. Gupta,Kumar, Sharma. Classical Mechanics, Pragati Prakashan publisher, Meerut,2004.
3. H.Goldstein, Classical Mechanics, Addision Wesley Publishing Company, Masssachusetts, 1961.
4. Gupta, Kumar, Elementary Statistical Mechanics, Pragati Prakashan publisher, Meerut,2004.

SUPPLEMENTARY READING:

1. Kiran C.Gupta, Classical mechanics of Rigid Bodies, New Age Publication,1997
2. R.K.Agarwal and Melvin Eisner, Statistical Mechanics, , New Age publisher,2011
3. E.S.R Gopal, Statistical Mechanics and Properties of Matter, The McMillan Company of India Ltd.,1976.

COURSE OUTCOMES (COs):

By the end of the course, the students will able to

CO1: Formulate scientific questions about the mechanics of a particle and system of particles.
CO2: Use D'Alembert's principle to derive the Lagrange equations of motion.
CO3: Identify the differences of Bose -Einstein, Fermi-Dirac and Maxwell – Boltzmann statistics.
CO4: Describe the relationship between the statistical mechanics with thermodynamics.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓		✓							✓	✓	✓	✓	✓		✓	
CO2	✓	✓		✓							✓	✓	✓	✓	✓		✓	
CO3	✓	✓		✓	✓		✓				✓	✓	✓	✓	✓		✓	
CO4	✓	✓		✓	✓		✓				✓	✓	✓	✓	✓		✓	

SEMESTER - I	19PHYC102 – ELECTRONICS	Credit:4 Hours:4

LEARNING OBJECTIVES:

- To gain in-depth knowledge about semiconductor devices.
- To learn amplifiers, oscillators using transistors.
- To study the applications of operational amplifiers.
- To familiarise various classifications of Semiconductor Memories and
- To know about the fabrication concepts of Integrated circuits.

UNIT– 1: SEMICONDUCTOR DEVICES

UJT, JFET, MOSFET - Operation and static characteristics. SCR - Two transistor analogy, static characteristics, Half wave, Full wave and bridge rectifier. DIAC, TRIAC - static characteristics.

UNIT– 2: AMPLIFIERS AND OSCILLATORS

Transistors: h-parameters - analysis of amplifiers using h - parameters. RC coupled amplifier- single stage-two stage - push pull amplifier - feedback principle and Barkhausen criterion - Hartley, Colpit's and Phase shift oscillators using transistors.

UNIT– 3: OPERATIONAL AMPLIFIERS - APPLICATIONS

Operational Amplifier - Characteristics - Instrumentation amplifier- applications. Differential input and differential output amplifier- V to I and I to V converter. Op. amp. stages-Equivalent circuits - sample and Hold circuits. Solving simultaneous and differential equation. Applications of IC 741: monostable, bistable Multivibrators, Oscillators - Wein bridge, voltage controlled oscillators, wave form generators - square wave, triangular wave, saw tooth wave.

UNIT– 4: SEMICONDUCTOR MEMORIES

Classification of memories: ROM - RAM. Sampling theorem. DAC-weighted resistor network, binary ladder network. ADC - successive approximation, dual slope, counter method, voltage to frequency conversion method. Programmable Logic Array. Charge Coupled Device memory.

UNIT– 5: INTEGRATED CIRCUITS

Basic monolithic ICs - epitaxial growth - masking and etching - diffusion of impurities. Transistors for monolithic circuit, monolithic diodes, resistors, capacitors and Inductors. Monolithic circuit layout. Logic families - RTL, TTL, CMOS, interfacing CMOS and TTL.

TEXT BOOKS:

1. Satnam P.Mathur, Electronic Devices - Applications and Integrated Circuits, John Wiley and Sons, 1986.
2. Jacob Millman and C.Halkias, Electronic Devices and Circuits, Jacob Millman and C.Halkias, Tata McGraw Hill Publications, 1991.
3. Bhotkar,Integrated Circuits, Khanna Publishers, 2010.
4. R.P.Jain, Modern Digital Electronics, Tata McGraw Hill, 1991.

SUPPLEMENTARY READING:

1. Jacob Millman and Grabel, Microelectronics, McGraw Hill, 2^{nd} Edn., 1987.
2. Jacob Millman and Halkias, Integrated Electronics, McGraw Hill, 1972.
3. Bapat, Electronic Circuits, Linear and Digital, Tata McGraw Hill, 1991

COURSE OUTCOMES (COs):

By the end of the course, the students will be able to

CO1: Understand the concept of various semiconductor devices by learning their characteristics.
CO2: Analyze the parameters of amplifiers, oscillators using transistors and familiarize with applications of operational amplifiers.
CO3: Understand the classifications of Semiconductor Memories.
CO4: Understand the concepts of Integrated circuits.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓	✓	✓	✓	✓	✓				✓	✓		✓			✓	✓
CO2	✓	✓	✓	✓	✓	✓	✓				✓	✓		✓			✓	✓
CO3	✓	✓	✓	✓	✓	✓	✓				✓	✓		✓			✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓											

SEMESTER - I	**19PHYC103 - MATHEMATICAL PHYSICS – I**	**Credit:4** **Hours:4**

LEARNING OBJECTIVES:

- To develop knowledge in mathematical physics and its applications.
- To develop expertise in mathematical techniques required in physics.
- To enhance problem solving skills.
- To enable students to formulate, interpret and draw inferences from mathematical solutions.

UNIT– 1: VECTOR ANALYSIS AND VECTOR SPACES

Concept of gradient, divergence and curl - Gauss's divergence theorem, Green's theorem and Stoke's theorem (statement and proof) - Orthogonal curvilinear coordinates - Expression for gradient, divergence, curl and Laplacian in cylindrical and spherical co-ordinates (Theory).

Linearly dependent and independent sets of vectors - Inner product (problems)- Schmidt's orthogonalization process.

UNIT– 2: MATRICES

Types of Matrices and their properties, Rank of a Matrix, Eigenvalue Equations and their solutions, Theorems on Matrices; Diagonalisation and Diagonalisation of different matrices; Cayley-Hamilton's theorem; Problems.

UNIT– 3: TENSOR ANALYSIS

Definition of Tensors – Contravariant, covariant and mixed tensors – addition and subtraction of Tensors – Summation convention- Symmetry and Anti-symmetry Tensor – Contraction and direct product – Quotient rule- Pseudo tensors, Levi-Civita Symbol - Dual tensors, irreducible tensors-Metric tensors-Christoffel symbols – Geodesics.

UNIT– 4: COMPLEX VARIABLE

Functions of complex variable-Analytic functions-Cauchy- Riemann equations-integration in the Complex plane-Cauchy's theorem- Cauchy's integral formula-Taylor and Laurent expansions- Singular Points- Cauchy's residue theorem - poles - evaluation of residues - evaluation of definite integrals.

UNIT– 5: GROUP THEORY

Definition - Subgroups - Cyclic groups and abelian groups - Homomorphism and isomorphism of groups - Classes - Symmetry operations and symmetry elements - Representations of groups - Reducible and irreducible representations - Character tables for simple molecular types (C_{2v} and C_{3v} point group molecules).

TEXT BOOKS:

1. B.D. Gupta, Mathematical Physics, Vikas Publishing House Pvt. Ltd, 1995.
2. B.S.Rajput, Mathematical Physics, Pragati Prakashan, 20th Edition, 2008.
3. H.K. Dass and Rama Verma, Mathematical Physics, S.Chand and Company Ltd, 2010.
4. P.K. Chattopadhyay, Mathematical Physics, Wiley Eastern Limited, 1990.

SUPPLEMENTARY READING:

1. Charlie Harper, Introduction to Mathematical Physic, Prentice Hall of India Pvt. Ltd, 1993.
2. L.A. Pipes and L.R. Havevill, Applied Mathematics for Engineers and Physicists, McGraw Hill Publications Co., 3rd Edition, 1971.
3. Murray R. Spigel, Theory and Problems of Laplace Transforms, Schaum's outline series, McGraw Hill, 1986.
4. A.W. Joshi, Matrices and Tensors in Physics, Wiley Eastern Limited, 3rd Edition, 1995.

COURSE OUTCOMES (COs):

By the end of the course, the students will be able to

CO1: Develop knowledge in mathematical physics and its applications.

CO2: Understand the use of complex variables for solving definite integral.

CO3: Understand the applications of group theory in all the branches of Physics problems.

CO4: Enable students to formulate, interpret and draw inferences from mathematical solutions.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓	✓		✓	✓					✓	✓	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓								✓	✓	✓	✓				
CO3	✓	✓	✓								✓	✓	✓	✓				
CO4	✓	✓	✓		✓	✓					✓	✓	✓	✓	✓	✓	✓	✓

SEMESTER - I	19PHYP104- PRACTICAL – I	Credit:6 Hours:9

LEARNING OBJECTIVES:

- To gain knowledge regarding the physics fundamentals and an instrumentation to arrive solution for various problems.
- To study the aspects related to the application side of the experiments
- To understand the usage of basic laws and theories to determine various properties of the materials given.
- To provide a hands-on learning experience such as in measuring the basic concepts and applications of microprocessor.

(Any Sixteen Experiments)

1. Young's modulus of a specimen plate- by Newton's interference method.
2. Bi-prism on spectrometer- Wavelength (λ) and Refractive index (μ) of a liquid-using Laser source.
3. Charge of an electron- Spectrometer
4. Study of Hall effect in semiconductors.
5. Polarizability of Liquids- Hollow prism on spectrometer.
6. Hg-Cu spectrum- Hartmann's constants and wavelength.
7. Planck's constant.
8. Zeeman Effect.
9. Thermoluminescence
10. Krishnan Torsion Balance.
11. Microprocessor 8085 - Addition, Subtraction, Multiplication & Division
12. Microprocessor 8085 - Logical operation
13. Microprocessor 8085 - Solving expression, Factorial of N Numbers
14. Microprocessor 8085 - Code conversion

15. Microprocessor 8085 – Flashing and Rolling of Name display
16. Microprocessor 8085 – Stepper Motor
17. Microprocessor 8085 – ADC Interfacing
18. Microprocessor 8085 – DAC Interfacing
19. Microprocessor 8085 – Biggest and Smallest Numbers
20. Microprocessor 8085 – Ascending and Descending Order

COURSE OUTCOMES (COS):

CO1: Understand the basic laws and theories regarding the various properties of the materials.
CO2: Understand the given concepts and its physical significance

CO3: Apply the theory to design the basic electronic circuits
CO4: Provide a hands-on learning experience and understand the basic concepts and applications of microprocessor.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓	✓	✓	✓	✓					✓			✓		✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓					✓			✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓

SEMESTER - II	**19PHYC201- MATHEMATICAL PHYSICS – II**	**Credit:4** **Hours:4**

LEARNING OBJECTIVES:

- To develop knowledge in mathematical physics and its applications.
- To develop expertise in mathematical techniques required in physics.
- To enhance problem solving skills.
- To enable students to formulate, interpret and draw inferences from mathematical solutions.

UNIT– 1: DIFFERENTIAL EQUATIONS

Homogeneous linear equations of second order with constant coefficients and their solutions – ordinary second order differential with variable coefficients and their solution by power series and Frobenius methods – extended power series method for indicial equations.

UNIT– 2: SPECIAL FUNCTIONS – I

Gamma and Beta function- Legendre's differential equation: Legendre polynomials - Generating functions - Recurrence relation - Rodrigue's formula - Orthogonality; Bessel's differential equation: Bessel polynomials - Generating functions - Recurrence relation - Rodrigue's formula – Orthogonality.

UNIT– 3: SPECIAL FUNCTIONS – II

Hermite differential equation – Generating functions – Hermite polynomials - Recurrence relations – Rodrigue's formula - Orthogonality: Laguerre differential equations – Generating functions - Laguerre polynomials - Recurrence relation - Rodrigue's formula – Orthogonality.

UNIT– 4: PARTIAL DIFFERENTIAL EQUATIONS

Solution of Laplace Differential Equation - Two dimensional flow of heat in cartesian and cylindrical co-ordinates. Solution of heat flow equation in one dimension - Solution of wave equation - Transverse vibrations of a stretched string (Theory).

UNIT– 5: INTEGRAL TRANSFORMS

Fourier transforms - cosine and sine transforms - Linearity theorem - Parseval's theorem - solution of differential equation. Laplace transforms - Definition - Linearity, shifting and change of scale properties. Inverse Laplace transforms – Definition - Problems - Solution of differential equation (problems using the above methods).

TEXT BOOKS:

1. B.D. Gupta, Mathematical Physics, Vikas Publishing, 1995.
2. B.S. Rajput, Mathematical Physics, Pragati Prakashan, 20th Edition, 2008.
3. H.K. Dass and Rama Verma, Mathematical Physics, Chand and Company Ltd, 2010.
4. P.K. Chattopadhyay, Mathematical physics, Wiley Eastern Limited, 1990.

SUPPLEMENTARY READING:

1. Charlie Harper, Introduction to Mathematical Physics, Prentice Hall of India Pvt. Ltd, 1993.
2. L.A. Pipes and L.R. Havevill, Applied Mathematics for Engineers and Physicists, 3rd Edition, McGraw Hill, 1971.
3. Murray R. Spigel Theory and problems of Laplace Transforms, International edition, McGraw Hill, 1986.

COURSE OUTCOMES (COs):

By the end of the course, the student will be able to

CO1: Develop knowledge in mathematical physics and its applications.
CO2: Develop expertise in mathematical techniques required in physics.
CO3: Use differential equations and special functions to solve mathematical problems of interest in Physics.
CO4: Enable students to formulate, interpret and draw inferences from mathematical solutions.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓	✓		✓	✓					✓	✓	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓								✓	✓	✓	✓				
CO3	✓	✓	✓								✓	✓	✓	✓				
CO4	✓	✓	✓		✓	✓					✓	✓	✓	✓	✓	✓	✓	✓

SEMESTER - II	19PHYC202- CONDENSED MATTER PHYSICS – I	Credit:4 Hours:4

LEARNING OBJECTIVES:

- This course gives an insight into the basic elements of the physics of solid and in particular the study of the structure of crystalline solids and their physical properties.
- To develop a deep understanding of how condensed matter is characterized on the atomic scale.
- Understanding of Lattice vibrations, approximations, phonons and heat capacity to know the correlation between the structure and thermal properties of the materials.

UNIT– 1: CRYSTAL PHYSICS: CRYSTAL STRUCTURE

Lattice representation - Simple symmetry operations - Bravais Lattices, Unit cell, Wigner -Seitz cell - Miller planes and spacing - Characteristics of cubic cells - Structural features of NaCl, CsCl, Diamond, ZnS – Close packing.

Crystal Binding*:* Interactions in inert gas crystals and cohesive energy – Lennard – Jones potential - Interactions in ionic crystals and Madelung energy - Covalent bonding – Heitler – London Theory – Hydrogen bonding – metallic bonding.

UNIT– 2: DIFFRACTION OF WAVES AND PARTICLES BY CRYSTALS

X-rays and their generation - Moseley's law – Absorption of X-rays (Classical theory) – Absorption Edge – X-ray diffraction – The Laue equations – Equivalence of Bragg and Laue equations – Interpretation of Bragg equation – Ewald construction - Reciprocal lattice – Reciprocal lattice to SC, BCC and FCC crystals- Important properties of the Reciprocal lattice – Diffraction Intensity - The Powder method – Powder Diffractometer - The Laue method -The Rotating Crystal method - Neutron Diffraction - Electron diffraction.

UNIT– 3: CRYSTAL IMPERFECTIONS AND ORDERED PHASES OF MATTER

Point imperfections – Concentrations of Vacancy, Frenkel and Schottky imperfections – Line Imperfections – Burgers Vector – Presence of dislocation – surface imperfections-Polorans – Excitons. Ordered phases of matter: Translational and orientation order - Kinds of liquid crystalline order - Quasi crystals - Superfluidity.

UNIT– 4: LATTICE DYNAMICS

Theory of elastic vibrations in mono and diatomic lattices - Phonons – Dispersion relations - Phonon momentum.

Heat Capacity

Specific heat capacity of solids – Dulong and Petit's law - Vibrational modes - Einstein model - Density of modes in one and three dimensions - Debye Model of heat capacity.

Anharmonic Effects

Explanation for Thermal expansion, Conductivity and resistivity – Umklapp process.

UNIT– 5: THEORY OF ELECTRONS

Energy levels and Fermi-Dirac distribution for a free electron gas – Periodic boundary condition and free electron gas in three dimensions – Heat capacity of the electron gas – Ohm's law, Matthiessen's rule – Hall effect and magnetoresistance – Wiedemann – Franz law.

Nearly free electron model and the origin and magnitude of energy gap – Bloch functions - Bloch theorem - Motion of an electron in a periodic potential – Kronig – Penney model - Approximate solution near a zone boundary –Metals, semiconductors and insulators – effective mass – Limitations of K-P model – Tight binding approach - Construction of Fermisurfaces: Reduced and periodic zone schemes of construction- de Haas – van Alphen effect.

TEXT BOOKS:

1. Charles Kittle, Introduction to Solid State Physics, Wiley India Pvt. Ltd., New Delhi, 7th Edition, 2004.
2. M.A. Wahab, Solid State Physics, Structure and Properties of the Materials. Narosa, New Delhi, 1999.
3. S.O. Pillai, Problems and Solutions in Solid State Physics, New Age International Publishers, New Delhi, 1994.

SUPPLEMENTARY READING:

1. Rita John, Solid State Physics, Tata Mc Graw Hill Publications, 2014.
2. J.D. Patterson, B.C. Bailey, Solid -State Physics: Introduction to the Theory, Springer Publication, 2007.
3. M.Ali Omar, Elementary Solid -State Physics – Principle and Applications, Persion, 1999.
4. N.W. Aschroft and N.D., Mermin, Solid -State Physics, Rhinehart and Winton, New York. 1976.
5. A.J. Dekker, Electrical Engineering Materials, Prentice Hall of India, 1975.

COURSE OUTCOMES (COs):

By the end of the course, the student will be able to

CO1: Describe different types of crystal structures.
CO2: Understand the types of lattice vibrations and heat conduction.
CO3: Describe and understand the various imperfections in crystals.
CO4: Understand the band-structure of the solid.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓						✓			✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓			✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓

SEMESTER - II	19PHYC203 - ELECTROMAGNETIC THEORY	Credit:4 Hours:4

LEARNING OBJECTIVES:

- To understand the nature of electric and magnetic fields and the intricate connection between them.
- To develop a strong background in electromagnetic theory, understand and use various mathematical tools to solve Maxwell equations in problems of wave propagation and radiation.
- To develop skills on solving analytical problems in electromagnetism.

UNIT– 1: ELECTROSTATICS

Coulomb's law; the electric field – line, flux and Gauss's Law in differential form - the electrostatic potential; conductors and insulators; Gauss's law - application of Gauss's law – curl of E - Poisson's equation; Laplace's equation – work and energy in electrostatics – energy of a point charge distribution – energy of continuous charge distribution – induced charges – capacitors. Potentials: Laplace equation in one dimension and two dimensions – Dielectrics – induced dipoles – Gauss's Law in the presence of dielectrics.

UNIT– 2: MAGNETOSTATICS

Lorentz force – magnetic fields – magnetic forces – currents – Biot-Savart Law – divergence and curl of B – Ampere's Law – Electromagnetic induction - comparison of magnetostatics and electrostatics – Magnetic vector potential. Magnetization: effect of magnetic field on atomic orbit – Ampere's Law in magnetized materials – ferromagnetism.

UNIT– 3: ELECTROMOTIVE FORCE

Ohm's Law – electromotive force – motional emf – Faraday's Law – induced electric field – inductance – energy in magnetic field – Maxwell's equation in free space and linear isotropic media – continuity equation – Poynting theorem.

Electromagnetic waves in vacuum: Waves in one dimension – wave equation – sinusoidal waves – reflection and transmission – Polarization.

UNIT– 4: ELECTROMAGNETIC WAVES

The wave equation for E and B – Monochromatic Plane waves – energy and momentum in electromagnetic waves – electromagnetic waves in matters –TE waves in rectangular wave guides – the co-axial transmission line. Potentials: potentials and fields – scalar and vector potentials – Gauge transformation – Coulomb Gauge and Lorentz Gauge – Lorentz force law in potential form.

UNIT – 5: APPLICATION OF ELECTROMAGNETIC WAVES

Boundary conditions at the surface of discontinuity – Reflection and refraction of E.M waves at the interface of non – Conducting media – Kinematic and dynamic properties – Fresnel's equation – Electric field vector 'E' parallel to the plane of incidence and perpendicular to the plane of incidence – Reflection and transmission co-efficients at the interface between two non–Conducting media – Brewster's law and degree of polarization – Total internal reflection.

TEXT BOOKS:

1. SathyaPrakash, Electromagnetic Theory and Electrodynamics, Kedarnath Ramnath and Co, 2017.
2. B.B Laud, Electromagnetics, Wiley Eastern Company, 2000.
3. Wazed Miah, Fundamentals of Electromagnetics, Tata McGraw Hill, 1980.

SUPPLEMENTARY READING:

1. John R.Reitz, Frederick J Milford and Robert W.Christy, Fundamentals of Electromagnetic Theory, Narosa Publishing House, New Delhi, Third edition, 1998.
2. J.D. Jackson, Classical Electrodynamics, Wiley Eastern Limited, II Edition, 1993.
3. Narayana rao, Basic Electromagnetics with Application, , (EEE) Prentice Hall, 1997.
4. David J.Griffths, Introduction to Electrodynamics –Pearson, 4^{th} Edn, 2000 .

COURSE OUTCOMES (COs):

By the end of the course, the student will be able to

CO1: Applying vector calculus operations and developing knowledge of vector fields and scalar fields

CO2: Describing the fundamental nature of static fields, including steady current, static electric and magnetic fields

CO3: Formulating potential problems within electrostatics, magnetostatics and stationary current distributions in linear, isotropic media etc.,

CO4: Applying Maxwell's equations and their application to boundary conditions, wave equations, and Poynting's power-balance theorem.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓												✓		✓	✓	
CO2	✓	✓	✓	✓	✓	✓	✓	✓						✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓						✓		✓	✓	✓
CO4	✓	✓												✓		✓	✓	

SEMESTER - II	19PHYP204 - PRACTICAL – II	Credit:6 Hours:9

LEARNING OBJECTIVES:

- To gain knowledge regarding the physics fundamentals and an instrumentation to arrive solution for various problems.
- To study the aspects related to the application side of the experiments
- To understand the usage of basic laws and theories to determine various properties of the materials given.
- To provide hands-on learning experience such as in measuring the basic concepts and applications of laser and microprocessors.

(Any Sixteen Experiments)

1. Michelson Interferometer – Wavelength Determination.
2. Energy gap – Four Probe Apparatus.
3. Elastic constants of Glass- Cornu's interference method (Hyperbolic fringes).
4. Solar Spectrum
5. Thermistor characteristics-Band gap energy
6. Reflection grating-Spectrometer
7. Ultrasonic diffractometer – Velocity and compressibility of liquids
8. Characteristics of He-Ne Laser.
9. Diffraction at straight edge using Laser.
10. Magnetostriction
11. Numerical Aperture and Acceptance Angle-Fibre Optics
12. Microprocessor 8086 I – Addition and Subtraction (16 & 32 bits)
13. Microprocessor 8086 II –Multiplication and Division (16 & 32 bits)
14. Microprocessor 8086 - Biggest and Smallest Numbers
15. Microprocessor 8086 - Code conversion
16. Microprocessor 8086 - Solving expression, Factorial of N Numbers
17. Microprocessor 8086 – Sum of elements in an array and factorial
18. Microprocessor 8086 – Sorting of N Elements (Ascending and Descending Order)
19. Microprocessor 8086 – String Operations
20. Wave form generations using 8086.

COURSE OUTCOMES (COS):

CO1: Understand the basic laws and theories regarding the various properties of the materials.
CO2: Understand the given concepts and its physical significance
CO3: Apply the theory to design the basic electrical circuits
CO4: provide a hands-on learning experience and understand the basic concepts and applications of laser and microprocessor.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓	✓	✓	✓	✓					✓			✓		✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓					✓			✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓

SEMESTER - III	19PHYC301 - QUANTUM MECHANICS – I	Credit:4 Hours:4

LEARNING OBJECTIVES:

- To study the fundamentals of wave mechanics.
- To study the stationary state and eigen spectrum of systems using time dependent Schrodinger equation.
- To solve the exactly soluble eigen value problems.
- To know the matrix formulation of quantum theory and how it can be used to Understand the equation of motion.
- To understand the theory of identical particles and Angular momentum.

UNIT– 1: FOUNDATIONS OF WAVE MECHANICS

Postulates of wave mechanics -adjoint and self-adjoint operators-degeneracy-eigen value, eigen functions-Hermitian operator- parity - observables - Physical interpretation-expansion coefficients-momentum eigen functions-Uncertainty principle-states with minimum value-commuting observables.

Matter waves- Equation of motion- Schrodinger equation for the free particle – physical interpretation of wave function-normalized and orthogonal wave functions-expansion theorem-admissibility conditions- stationary state solution of Schrodinger wave equation - expectation values-probability current density- Ehrenferts theorem.

UNIT– 2: STATIONARY STATE AND EIGEN SPECTRUM

Time independent Schrodinger equation - Particle in a square well potential – Bound states – eigen values, eigen functions –Potential barrier – quantum mechanical tunnelling-alpha emission.

Identical Particles – symmetry and antisymmetric wave functions – exchange degeneracy – Spin and statistics: Pauli's exclusion principle-Slater determinant-spin and Pauli's matrices.

UNIT– 3: EXACTLY SOLUBLE EIGENVALUE PROBLEMS

One dimensional linear harmonic oscillator – properties of stationary states- abstract operator method - Angular momentum operators- commutation relation- spherical symmetry systems -Particle in a central potential – radial wave function – Hydrogen atom: solution of the radial equation – stationary state wave functions – bound states-the rigid rotator: with free axis-in a fixed plane-3-Dimentional harmonic oscillator.

**UNIT– 4: MATRIX FORMULATION OF QUANTUM THEORY,
EQUATION OF MOTION & ANGULAR MOMENTUM**

Quantum state vectors and functions- Hilbert space-Dirac's Bra-Ket notation-matrix theory of Harmonic oscillator –Equation of motions-Schrodinger, Heisenberg and Interaction representation.

Angular momentum -commutation relation of J_Z, J_+, J_- - eigen values and matrix representation of J^2, J_Z, J_+, J_- – Spin angular momentum – spin ½ , spin-1- addition of angular momenta- Clebsch-Gordan coefficients.

UNIT– 5: SCATTERING THEORY

Kinematics of scattering process - wave mechanical picture- Green's functions – Born approximation and its validity –Born series – screend columbic potential scattering from Born approximation.

Asymptotic behavior – phase shift – scattering amplitude in terms of phase shifts – differential and total cross sections – optical theorem – low energy scattering – resonant scattering – non-resonant scattering-scattering length and effective range– Ramsauer-Townsend effect – scattering by square well potential.

TEXT BOOKS:

1. G. Aruldhas, A Text book of Quantum Mechanics, Prentice Hall of India Pvt., Ltd., 2002
2. Satya Prakash, Quantum Mechanics, Kedarnath Ramnath and Co. Publications, 2018.
3. V. K. Thankappan, Quantum Mechanics, New Age International (P) Ltd. Publication, Second Edition, 2003.

SUPPLEMENTARY READING:

1. A. K. Ghatak and Lokanathan, Quantum Mechanics – Theory and applications, Macmillan India Ltd Publication, Fifth Edition, 2015.
2. Leonard I. Schiff, Quantum Mechanics, McGraw-Hill International Publication, Third Edition, 1968.
3. E. Merzbacher, Quantum Mechanics, John Wiley Interscience Publications, Third Edition, 2011.
4. Claude Cohen-Tannoudji, Bernard Diu, Franck Laloë , Quantum Mechanics (Vol .I), John Wiley Interscience Publications, First Edition, 1991.
5. Pauling & Wilson, Quantum Mechanics, Dover Publications, New Edition, 1985.
6. R. Shankar, Principle of Quantum Mechanics, Plenum US Publication, Second Edition, 1994.

COURSE OUTCOMES (COs):

By the end of the course, the student should be able to

CO1: Study the stationary state and eigen spectrum of systems using time dependent Schrodinger equation.
CO2: Know to solve the exactly soluble eigen value problems.
CO3: Know the matrix formulation of quantum theory and how it can be used to understand the equation of motion.
CO4: Understand the theory of identical particles and Angular momentum.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓		✓							✓	✓	✓		✓		✓	✓
CO2	✓	✓		✓							✓	✓	✓		✓		✓	
CO3	✓	✓		✓	✓		✓				✓	✓	✓	✓	✓	✓	✓	
CO4	✓	✓		✓	✓		✓				✓	✓	✓		✓	✓	✓	

SEMESTER - III	19PHYC302 - CONDENSED MATTER PHYSICS – II	Credit:4 Hours:4

LEARNING OBJECTIVES:

- This course develops analytical thinking to understand the phenomenon that decide various properties of solids.
- Provides a valuable theoretical introduction and overview of the fundamental application of physics of solids.
- To impart the basic knowledge about superconductors and high temperature super conductors.

UNIT– 1: THEORY OF DIELECTRICS

Dipole moment – Polarization – The electric field of a dipole – Local electric field at an atom – Clausius –Mosotti equation - Dielectric constants and its measurements - Polarizability – The Classical theory of electronic polarizability – Ionic polarizabilities - Orientational polarizabilities - The polarizability catastrophe - Dipole orientation in solids - Dipole relaxation and dielectric losses – Debye Relaxation time - Relaxation in solids - Complex dielectric constants and the loss angle - Frequency and temperature effects on Polarization – Dielectric breakdown and dielectric loss

UNIT– 2: THEORY OF FERROELECTRICS AND PIEZO ELECTRICS

Ferroelectric Crystals – Classifications of Ferroelectric crystals - Dipole theory of ferroelectricity – Landau Theory of the phase transition – Second order Transition – First Order Transition - Ferroelectric Transition - One-Dimensional Model of the Soft Mode of Ferroelectric Transitions – Antiferroelectricity - Ferroelectric domains – Ferroelectric domain wall motion – Piezoelectricity - Phenomenological Approach to Piezoelectric Effects - Piezoelectric Parameters and Their Measurements - Piezoelectric Materials

UNIT– 3: MAGNETIC PROPERTIES OF MATERIALS

Terms and definitions used in magnetism – Classification of magnetic materials – Atomic theory of magnetism – The quantum numbers- The origin of permanent magnetic moments – Langevin’s classical theory of diamagnetism – Sources of paramagnetism – Langevin’s classical theory of paramagnetism – Quantum theory of paramagnetism – Paramagnetism of free electrons - Ferromagnetism – The Weiss molecular field theory – Temperature dependence of Spontaneous magnetization – The physical origin of Weiss Molecular field - Ferromagnetic domains - Domain theory – Antiferromagnetism – Ferrimagnetism – Structure of Ferrite.

UNIT– 4: SUPERCONDUCTIVITY

Occurence of super conductivity - Destruction of super conductivity by magnetic fields - Meissner Effect – Type I and Type II Super conductors - Heat Capacity - Energy gap - Microwave and infrared properties - Isotope effect - Thermodynamics of the superconducting transition - London equation - Coherence Length - BCS theory of superconductivity, BCS ground state - Flux quantisation in a super conduction ring - Duration of persistence currents - Single particle tunnelling - DC Josephson effect - AC Josephson effect - Macroscopic quantum interference – High temperature super conductors – Applications.

UNIT– 5: PHYSICS OF NANOSOLIDS

Definition of nanoscience and nanotechnology – Preparation of nanomaterials – Surface to volume ratio – Quantum confinement – Qualitative and Quantitative description – Density of states of nanostructures – Excitons in Nano semiconductors – Carbon in nanotechnology – Buckminsterfullerene – Carbon nanotubes – Nano diamond – BN nano tubes – Nanoelectronics – Single electron transistor – Molecular machine – nano biometrics.

TEXT BOOKS:

1. Charles Kittel, Introduction to solid state physics, Wiley India Pvt. Ltd., New Delhi, 7th Edition, 2004.
2. K.K.Chattopadhyay, A.N.Banerjee, Introduction to Nanoscience and Nanotechnology, PHI Learning Private Ltd., Delhi 2014.
3. S.O. Pillai, Problems and Solutions in Solid State Physics, New Age international publishers, New Delhi, 1994.

SUPPLEMENTARY READING:

1. Rita John, Solid State Physics, Tata Mc Graw Hill Publications, 2014.
2. M.A. Wahab, Solid State Physics, structure and properties of the materials. Narosa, New Delhi, 1999.
3. M.Tinkham, Introduction to Superconductivity, Tata McGraw Hill, New Delhi, 1996.
4. A.J. Dekker, Electrical Engineering Materials, Prentice Hall of India, 1975.
5. Kwan Chi Kao, Dielectric Phenomena in solids with emphasis on physical concepts of electronic processes, Elsevier Academic press, 2004.

COURSE OUTCOMES (COs):

By the end of the course, the student will be able to

CO1: Understand the dielectric properties of the solid systems.

CO2: Understand the ferroelectric and piezoelectric properties of the solid systems and its application.

CO3: Understand deeply the electrical and magnetic properties of crystalline solids with theoretical background.

CO4: Understand the theoretical basis of nanotechnology and carbon in nanotechnology.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓						✓			✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓			✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓

SEMESTER - III	19PHYC303 - NUCLEAR AND ELEMENTARY PARTICLE PHYSICS	Credit:4 Hours:4

LEARNING OBJECTIVES:

- To understand the forces of binding the nucleons in detail and the perspective of various models proposed with dipole and quadropole moments of the nucleus
- To make them realize the cause of various nuclear particles in the strong short range interaction among the nucleons.
- To understand the concepts of elementary particles.

UNIT– 1: NUCLEAR FORCES

Characteristics of Nucleus Forces – Exchange forces and tensor forces – charge independence-Spin dependence of Nucleus Forces - Meson theory of nuclear forces- Ground state of deuteron- Nucleon-nucleon scattering singlet and triplet parameters – Nucleon-Nucleon scattering: Cross-section, Differential Cross-section, Scattering Cross-sections – magnetic moment- Quadrupole moment –S and D state admixtures - Effective range theory of n-p scattering at low energies.

UNIT– 2: NUCLEAR MODELS

Binding energy & mass defect – Weizacker's formula – mass parabola - Liquid drop model - Bohr -Wheeler theory of fission- Activation energy for fission- Shell model- Spin –Orbit coupling-Spins of nuclei- Magnetic moments – Schmidt lines- Electric quadrupole moments - Collective model of Bohr and Mottelson: Nuclear vibration – Nuclear rotation –Nelson model.

UNIT– 3: NUCLEAR REACTIONS

Nuclear reaction - Q- value – Nuclear reaction cross section – Direct Nuclear Reactions: Knock out reaction, Pick-up reaction, Stripping reaction – Compound nucleus theory – Formation – Disintegration energy levels – Partial wave analysis of Nuclear reaction cross-section - Resonance Scattering and Reaction cross-section (Breit-Wigner dispersion formula) – Scattering matrix - Reciprocity theorem – Breit -Wigner one level formula – Resonance scattering – Absorption cross section at high energy.

UNIT– 4: NUCLEAR FISSION AND FUSION

Nuclear fission- Energy release in fission reaction - Distribution of fission products-neutron emission in fission - Fissile and fertile materials - Bohr Wheeler theory. Nuclear chain reaction - Four factor formula - Nuclear reactors - Classification of reactors - Critical size of a reactor - Reactor materials.

Nuclear fusion – nuclear reaction in stars – Fusion reactors – Pinched discharge - Stellarator – Magnetic mirror systems.

UNIT– 5: ELEMENTRY PARTICLE PHYSICS

Classification of elementary particles - Types of interaction between elementary particles – Hadrons and leptons – Symmetry and conservation laws – Strangeness and associate production - CPT theorem – classification of hadrons – Quark model - Isospin multiples - SU(2)-SU(3) multiplets- Gell-Mann - Okubo mass formula for octet and decuplet hadrons – Phenomenology of weak interaction hadrons and leptons - Universal Fermi interaction – Elementary concepts of weak interactions.

TEXT BOOKS:

1. B. B. Cohen, Concepts of Nuclear Physics, TMGH, Bombay, 1971.
2. K. Krane, Introductory Nuclear Physics, Wiley, New York, 1987.
3. V. Devanathan Nuclear Physics, Alpha Science International Ltd.2011
4. D. Griffiths, Introduction to Elementary Particles, Wiley-Vch, 2nd Ed., 2008
5. S.N. Ghoshal, Nuclear Physics, S. Chand and Co., II edition, 1994.
6. D.C. Tayal, Nuclear Physics, Himalaya Publishing House Pvt., Ltd., V edition, 2018.
7. Irving Kaplan, Nuclear Physics, Narosa Publishing House, 2012.
8. B.N. Srivatsava,Basic Nuclear Physics and Cosmic Rays, Pragati Prakashan publications, Meerut, Edition: XVII, 2016.
9. M.L. Pandya and P.R.S Yadav, Elements of Nuclear Physics, Kedarnath Ramnath publications, Meerut, 2016.

SUPPLEMENTARY READING:

1. R. D. Evans, Atomic Nucleus, Mcgraw-Hill NY.1955.
2. J. M. Blatt and V. F. Weisskopf, Theoretical Nuclear Physics, Berlin 1979.
3. H. Enge, Addision-Wesley, Introduction to Nuclear Physics, Reading MA., 1975
4. R. R. Roy and B. P. Nigam, Nuclear Physics, Wiley Eastern, Madras, 1993.
5. A. Bohr andVol B. R. Mottelson, Nuclear Structure,. I (1969) and Vol.II (1975),

COURSE OUTCOMES (COs):

By the end of the Course, the student will be able to

CO1: Understand about nuclear forces and their dependence on various parameters.
CO2: Compare various nuclear models and properties of the nucleus.
CO3: Understand the Nuclear energy sources through various nuclear reactions.
CO4: Know the causes for short range interaction inside the nucleons with mathematical formulations.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	
CO2	✓	✓	✓	✓	✓						✓	✓		✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓			✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	

SEMESTER - III	19PHYP304 PRACTICAL –III	Credit:6 Hours:9

LEARNING OBJECTIVES:

- To gain knowledge regarding the physics fundamentals and an instrumentation to arrive solution for various problems.
- To study the aspects related to the application side of the experiments
- To understand the usage of basic laws and theories to determine various properties of the materials given.
- To provide a hands-on learning experience such as in measuring the basic concepts and applications of microcontroller.

(Any <u>Sixteen</u> Experiments)

1. Low field Hysterisis
2. Susceptibility of liquids using Guoy-Balance
3. Susceptibility of liquids by Quinke's method
4. Photo elastic constant
5. Hysterisis loop tracer
6. Cu-Salt (visible) Spectrum
7. Molecular constants-CN Band
8. Channel Spectrum
9. R.F.Oscillator- construction and determination of dielectric constant.
10. Ultrasonic velocity of liquid mixtures- Interferometer
11. Phase diagram of single component-using Potentiometer.
12. G.M. Counter characteristics
13. Microcontroller 8051 Experiment-I (Addition and Subtraction and Logical operations)
14. Microcontroller 8051 Experiment-II(Multiplication and Division and Solving expressions)
15. Microcontroller 8051 Experiment-III (Logical operations, 1's and 2's compliment)
16. Array Operations-I Microcontroller 8051(Sum of elements, biggest and smallest numbers)
17. Array Operations-II Microcontroller 8051(Ascending and descending order)
18. Microcontroller 8051 - Code conversion
19. Microcontroller 8051 – ADC interfacing
20. Microcontroller 8051 - Stepper motor interfacing

COURSE OUTCOMES (COS):

CO1: Understand the basic laws and theories regarding the various properties of the materials.
CO2: Understand the given concepts and its physical significance
CO3: Apply the theory to design the basic electrical circuits
CO4: provide a hands-on learning experience and understand the basic concepts and applications of microcontroller.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓	✓	✓	✓	✓					✓			✓		✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓					✓			✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓

SEMESTER - IV	19PHYC401 - QUANTUM MECHANICS – II	Credit:4 Hours:4

LEARNING OBJECTIVES:

- To learn about the approximation methods for time independent and time dependent perturbation theory.
- To understand the kinematics of scattering process and partial wave analysis.
- To study the theory of relativistic quantum mechanics and field quantization.
- To study the quantum theory of atomic and molecular structures.

UNIT– 1 APPROXIMATION METHODS FOR TIME INDEPENDENT PROBLEMS

Time independent perturbation theory – stationary theory- Non-degenerate case: first and second order-Normal Helium atom– Zeeman effect without electron spin – Stark effect in hydrogen molecule - Degenerate case: Energy correction- Stark effect in hydrogen atom.

UNIT– 2: APPROXIMATION METHODS FOR TIME DEPENDENT PERTURBATION THEORY

Time dependent Perturbation theory - first order transitions – constant perturbation-transition probability: Fermi Golden Rule –Periodic perturbation –harmonic perturbation – adiabatic and sudden approximation.

Semi-classical theory of radiation: Application of the time dependent perturbation theory to semi-classical theory of radiation – Einstein's coefficients – absorption - induced emission- spontaneous emission – Einstein's transition probabilities- dipole transition - selection rules – forbidden transitions.

UNIT– 3: VARIATION METHOD

Variation method: Variation Principle – upper bound states- ground state of Helium atom – Hydrogen molecule-WKB approximation - Schrodinger equation-Asymptotic solution-validity of WKB approximation-solution near a turning point – connection formula for penetration barrier – Bohr-Summer field quantization condition- tunneling through a potential barrier.

UNIT– 4: QUANTUM THEORY OF ATOMIC AND MOLECULAR STRUCTURE

Central field approximation: Residual electrostatic interaction-spin-orbit interaction- Determination of central field: Thomas Fermi statistical method-Hartree and Hartree-Fock approximations (self consistent fields) – Atomic structure and Hund's rule.

Born-Oppenheimer approximation – An application: the hydrogen molecule Ion (H_2^+) – Molecular orbital theory: LCAO- Hydrogen molecule.

UNIT– 5: RELATIVISTIC QUANTUM MECHANICS & QUANTIZATION OF THE FIELD

Schrodinger relativistic equation- Klein-Gordan equation-charge and current densities – interaction with electromagnetic field- Hydrogen like atom – nonrelativistic limit- Dirac relativistic equation: Dirac relativistic Hamiltonian – probability density- Dirac matrices-plane wave solution – eigen spectrum – spin of Dirac particle – significance of negative eigen states – electron in a magnetic field – spin magnetic moment.

Quantization of wave fields- Classical Lagrangian equation- Classical Hamiltonian equation- Field quantization of the non-relativistics Schrodinger equation- Creation, destruction and number operators- Anticommutation relations- Quantization of Electromagnetic field energy and momentum.

TEXT BOOKS:

1. P. M. Mathews and K. Venkatesan, A Text book of Quantum Mechanics, Tata McGraw – Hill Publications, Second Edition, 2010.
2. Satya Prakash, Quantum Mechanics, Kedar Nath Ram Nath and Co. Publications, 2018.
3. Claude Cohen-Tannoudji, Bernard Diu, Franck Laloë , Quantum Mechanics (Vol. II), John Wiley Publications, 2008.

SUPPLEMENTARY READING:

1. V. K. Thankappan, Quantum Mechanics, New Age International (P) Ltd. Publication, Second Edition, 2003.
2. Franz Schwabl, Quantum Mechanics, Narosa Publications, Fourth Edition, 2007.
3. P.W. Atkins and R.S. Friedman, Molecular Quantum mechanics, Oxford University Press publication, Fifth Edition, 2010.
4. A. K. Ghatak and Lokanathan, Quantum Mechanics – Theory and Applications, Macmillan India Ltd Publication, Fifth Edition, 2015.
5. Leonard I. Schiff, Quantum Mechanics, McGraw-Hill International Publication, Third Edition, 1968.
6. E. Merzbacher, Quantum Mechanics, John Wiley Interscience Publications, Third Edition, 2011.
7. Edwin C.Kemble, Fundamental principles of Quantum mechanics with elementary applications, Dover Publications, ReIssue Edition, 2005.

COURSE OUTCOMES (COs):

By the end of the Course, the students will be able to

CO1: Apply and appreciate the approximation methods to various problems
CO2: Identify the time dependent and time independent cases
CO3: Grasp the developments in relativistic quantum mechanics
CO4: Evaluate the quantum field parameters

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓		✓							✓	✓	✓		✓		✓	✓
CO2	✓	✓		✓							✓	✓	✓		✓		✓	
CO3	✓	✓		✓	✓		✓				✓	✓	✓	✓	✓	✓	✓	
CO4	✓	✓		✓	✓		✓				✓	✓	✓		✓	✓	✓	

SEMESTER - IV	19PHYC402 – SPECTROSCOPY	Credit:4 Hours:4

LEARNING OBJECTIVES:

- To educate the students about the fundamental aspects of Rotational and Vibrational Spectroscopy.
- To import knowledge regarding the fundamental aspects of Resonance Spectroscopy.
- To expose the students to the effective applications of various molecular Spectroscopic techniques to study the chemical and structural properties of materials.

UNIT– 1: MICROWAVE SPECTROSCOPY

Rotation of Molecules – Rigid Rotor (Diatomic Molecules) – Expression for the Rotational Constant - Intensity of Spectral Lines – Effect of Isotopic Substitution - Molecular Parameters (Bond Length, Bond Angle, Dipole Moment) from Rotation Spectra – Techniques and Instrumentation.

UNIT– 2: INFRARED SPECTROSCOPY

Vibrational energy of a diatomic molecule- Infrared selection rules-Vibrating diatomic molecule-Diatomic vibrating rotator- Vibrations of polyatomic molecules-Fermi resonance-Rotation vibration spectra of polyatomic molecules-Normal modes of vibration in crystal-Interpretation of vibrational spectra-Group frequencies-IR spectrophotometer-Instrumentation-Sample handling techniques-Fourier Transform Infrared spectroscopy-Applications

UNIT– 3: RAMAN SPECTROSCOPY

Introduction-Theory of Raman scattering-Rotational Raman spectra-Vibrational Raman spectra-Mutual Exclusion principle-Raman spectrometer-Sample handling techniques-Polarization of Raman scattered light-Structure determination using IR and Raman spectroscopy-Raman investigation of phase transitions-Resonance Raman scattering-Nonlinear Raman phenomena-Preliminaries-Hyper Raman effect-Stimulated Raman scattering-Inverse Raman effect-Coherent Anti-Stokes Raman scattering .

UNIT– 4: NUCLEAR MAGNETIC AND ELECTRON SPIN RESONANCE SPECTROSCOPY

Basic principles – Quantum theory of NMR - magnetic resonance – relaxation processes – chemical shifts – spin-spin coupling - Spectra and molecular structure – Fourier Transform NMR –Instrumentation – Applications.

Basic principles – Quantum theory - g-factor – Nuclear Interaction and Hyperfine structure – Relaxation effects - Hyperfine interaction – line widths – ESR spectrometer – Instrumentation – applications.

UNIT– 5: NUCLEAR QUADRUPOLE RESONANCE AND MOSSBAUER SPECTROSCOPY

Basic theory - Nuclear Electric quadrupole interaction – Energy levels – Transition frequency – Excitation and Detection – Effect of magnetic field – Instrumentation – applications.

Mossbauer effect - recoilless emission and absorption - hyperfine interaction - chemical isomer shift - magnetic hyperfine and electric quadruple interactions – ` Instrumentation – applications.

TEXT BOOKS:

1. Colin N. Banwell and Elaine M. Mc Cash, Fundamentals of Molecular Spectroscopy, Mc Grow – Hill Education (India) Pvt. Ltd.,New Delhi, (5^{th}edition), 2013.
2. R.P Straughen and S. Walker, Spectroscopy (vol.I, II, III), Chapman & Hall , London, 1976.
3. G.R. Chatwal and S.K.Anand, Spectroscopy (Atomic and Molecular), Himalaya Publishing House (5^{th} edition), 2016.

SUPPLEMENTARY READING:

1. J.D.Graybeal, Molecular Spectroscopy, McGraw – Hill, New York, 1988.
2. Michael Hollas, Modern Spectroscopy,, John Wiley, New York, (4^{th} edition), 2004.
3. Walter S. Struve, Fundamentals of Molecular Spectroscopy, John Wiley and Sons, Ames, Iowa, 1989.
4. G. Aruldhas, Molecular Structure and Spectroscopy, PHI Learning Private Limited – Hall of India, 2^{nd} edition, 2007.

COURSE OUTCOMES (COs):

By the end of the Course, the student will be able to

CO1 : Appreciate the principle of spectroscopy in different regions of the EM spectrum.
CO2 : Relate the theory of spectroscopy to the study of molecular structure.
CO3 : Identify the appropriate spectral technique as an analytical tool to investigate the characteristics of materials.
CO4 : Outline and correlate for providing solution to interdisciplinary problem.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			✓		✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓

SEMESTER - IV	19PHYC403 - PHYSICS OF NANOMATERIALS	Credit:4 Hours:4

LEARNING OBJECTIVES:

- To dinstinguish nanomaterials from bulk materials.
- To apply their acquired knowledge in research level to synthesis and characterize the nanomaterials.
- To identify the various techniques to investigate the different properties such as optical, structural and morphology of nanoparticles.
- To select the nanomaterials for various applications.

UNIT– 1: INTRODUCTION

Introduction – History of nanotechnology - Classification of nanomaterials: Definition of – Zero, one and two dimension nano structures – Examples - Classification of synthesis methods. Surface energy – Chemical potential as a function of surface curvature – Electrostatic stabilization - Steric stabilization – DLVO theory.

UNIT– 2: SPECIAL NANOMATERIALS

Carbon Fullerenes and Nanotubes: Carbon fullerenes, Fullerene derived crystals, Carbon nanotubes. Micro and Mesoporous Materials: Ordered mesoporous structures, Random mesoporous structures, crystalline microporous materials. Core-shell structures: Metal-oxide structures, Metal-polymer structures, Oxide-polymer structures.

UNIT – 3: PROPERTIES

Physical properties of nanomaterials: Melting points, Lattice constants – Mechanical properties – Optical properties:-Surface Plasmon Resonance – Quantum size effects – Electrical property: Surface scattering, charge of electronic structure - Ferroelectrics and dielectrics: Variation of magnetism with size-Super para magnetism-Diluted magnetic semi conductor.

UNIT – 4: SYNTHESIS

Synthesis of nano materials: Physical vapour deposition - Chemical vapour deposition - Sol gel - Ball milling technique - Reverse miceller technique - Electro deposition. Nanostructures fabrication by physical techniques – Nano lithography – Nanomanipulator.

UNIT – 5: CHARACTERIZATION AND APPLICATIONS

Structural Characterization: X-Ray diffraction – Scanning Electron Microscopy (SEM) – Transmission Electron Microscopy(TEM) – Chemical Characterization: Optical spectroscopy: UV-Visible and Phototluminescence spectroscopy.

Applications: Molecular electronics and Nano electronics, Nano electromechanical systems- Colorants and pigments –DNA chips – DNA array devices – Drug delivery systems.

TEXT BOOKS:

1. Viswanathan B, Nano Materials, Narosa publishing house, 2010.
2. Pradeep T, The Essentials, Nano: Tata MC Graw-Hill publishing company limited, 2007.
3. Christof M. Niemeyer, Chad A. Mirkin,Nanobiotechnology: Concepts, Applications and Perspectives, 2004.

SUPPLEMENTARY READING:

1. Kenneth F. Klablunde, Nanoscale Materials in Chemistry, John Wiley and sons, Inc., 2001.
2. Wilson M, K Kannangara, G. Smilt, M. Simmons and B. Boguse, Nanotechnology, Overseas Press, 2005
3. Freitas R A, Landes., Nanomedicine, TX publication, 1996.

COURSE OUTCOMES (COs):

By the end of the course, the student will be able to

CO1: Distinguish nanomaterials from bulk materials..
CO2: Apply their acquired knowledge in research level to synthesis and characterize the nanomaterials.
CO3: Identify the various techniques to investigate the different properties such as optical, structural and morphology of nanoparticles.
CO4: Select the nanomaterials for various applications.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓
CO2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	
CO3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	

SEMESTER - IV	**19PHYP404 - PRACTICAL – IV**	**Credit:6** **Hours:9**

LEARNING OBJECTIVES:

- To gain knowledge regarding the physics fundamentals and an instrumentation to arrive solution for various problems.
- To study the aspects related to the application side of the experiments
- To understand the usage of basic laws and theories to determine various properties of the materials given.
- To provide a hands-on learning experience such as in measuring the basic concepts and applications of microcontroller.

(**Any S<u>ixteen</u> experiments**)

1. Spectrophotometer
2. Co-effeicient of linear expansion-Interference Method.
3. R.F. Oscillator- Dipolemoment of Liquids
4. Susceptibility of Salt solutions/ Solids-Guoy method
5. Susceptibility of liquid mixture- Quincke's method-Calculation of Bohr magneton.
6. Phase diagram-Two component system.
7. Molecular constants –AIO Band
8. Molecular constants- CN Band.
9. Cu-Salt spectrum ultra violet region.
10. Optical rotation of quartz.
11. G.M. Counter -Absorption co-efficient of a foil.
12. F.P. Etalon.
13. Dielectrics of Solids
14. Particle size analyzer using Laser.

15. Stark Effect.
16. Micro hardness of a Crystal.
17. 8051 Micro controller - Setting bits and Masking bits in an 8-bit number.
18. Microcontroller 8051 - Generate a delay.
19. Microcontroller 8051 - DAC interfacing.
20. Microcontroller 8051 – Display and Rolling of messages.

COURSE OUTCOMES (COS):

CO1: Understand the basic laws and theories regarding the various properties of the materials.
CO2: Understand the given concepts and its physical significance
CO3: Apply the theory to design the basic electrical circuits
CO4: provide a hands-on learning experience and understand the basic concepts and applications of microcontroller.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓	✓	✓	✓	✓					✓			✓		✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓					✓			✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓

SEMESTER - IV	19PHYPJ405- PROJECT	Credit : 6 Hours: 9

Learning Objectives:

To learn the basics of research work by carrying out selective academic and applied projects.

Course outcomes:

At the end of the course, the students will

CO1: Acquire the practical knowledge of understanding research problems.

CO2: Gain knowledge basic principles of various components of research

CO3: Apply the principles of chemistry in various fields

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓			✓			✓										
CO2	✓		✓	✓	✓				✓									
CO3	✓			✓	✓					✓				✓				
CO4	✓	✓			✓	✓	✓	✓		✓		✓	✓				✓	✓

DEPARTMENT ELECTIVE COURSES

SEMESTER - II	19PHYE205.1 - MICROPROCESSORS AND MICROCONTROLLER	Credit:3 Hours:3

LEARNING OBJECTIVES:

- To learn the architecture of 8085 microprocessor and its programming.
- To study the architecture of 8086 microprocessor.
- To familiarize the architecture of 8051 microcontroller and its programming
- To study the interfacing devices of microprocessor 8085.

UNIT – 1: MICROPROCESSORS 8085 ARCHITECTURE

Intel 8085 microprocessor: Introduction – Pin configuration- Architecture and its operations - Machine cycles of 8085. Interfacing of memory and I/O devices. Instruction classification: number of bytes, nature of operations- Instruction format. Vectored and non-vectored interrupts.

UNIT – 2: 8085 ASSEMBLY LANGUAGE PROGRAMMING

Instruction set: Data transfer operations - Arithmetic operations Logical operations – Branching and machine control operations. Addressing modes. Writing assembly language programs: Looping, counting and indexing. Counters and time delays - Stack - subroutine. Translation from assembly language to machine language

UNIT – 3: MICROPROCESSOR 8086

Intel 8086 microprocessor: Introduction – Architecture - Pin configuration- Operating modes: Minimum mode, Maximum mode. Memory addressing: 8-bit data from even and odd address bank, 16-bit data from even and odd address bank. Addressing modes. Interrupts: Hardware interrupts – Software interrupts –Interrupt priorities. Simple programs
.

UNIT – 4: MICROCONTROLLER 8051 ARCHITECTURE AND PROGRAMMING

Introduction to microcontroller and embedded system. Difference between microprocessor and microcontroller. 8051 microcontroller : Pin configuration, Architecture and Key features. 8051. Data types and directives Instruction set: Data transfer instructions - Arithmetic instructions – Logical instructions- Branching instructions- Single bit instructions. Addressing modes. Simple programs using 8051 instruction set.

UNIT – 5: INTERFACING OF MICROPROCESSOR 8085

Basic concepts of programmable device - 8255 Programmable Peripheral Interface (PPI) – interface of ADC and DAC. 8257 Direct Memory Access (DMA) controller. Basic concepts of serial I/O and data communication – interface of 8251 Universal Synchronous Asynchronous Receiver Transmitter (USART)

TEXT BOOKS:

1. Ramesh S. Gaonkar, Microprocessor Architecture, Programming and Applications with 8085/8080, New Age International 6th edition, 2013.
2. Douglas V., Microprocessors and Interfacing-Programming and Hardware, Hall, Tata McGraw Hill, 1993.
3. Kenneth J. Ayala, The 8051 Microcontroller Architecture, Programming and Applications. Penram International publishing Pvt. Ltd., second edit, 1996.

SUPPLEMENTARY READING:

1. A.P.Godse and D.A.Godse, Microprocessors and Microcontrollers, Technical Publications, Pune.
2. Badri Ram, Advanced Microprocessors and Interfacing, Tata McGraw Hill, 2001.
3. Muhammad Ali Mazidi and Janice Mazidi, The 8051 Microcontroller and Embedded systems, Pearson Education, 2000.

COURSE OUTCOMES (COs):

By the end of the course, the students will be able to

CO1: Describe basic concept and architecture of 8085 microprocessor and implement programs in 8085.

CO2: Learn the architecture of 8086 microprocessor.

CO3: Understand the architecture of 8051 microcontroller and develop assembly language programs.

CO4: Discuss concept of interfacing in microprocessor 8085.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓	✓	✓	✓	✓	✓				✓	✓		✓		✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓	✓				✓	✓		✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓	✓				✓	✓		✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓				✓	✓		✓		✓	✓	✓

SEMESTER - II	19PHYE205.2 - PHYSICS OF THE EARTH	Credit:3 Hours:3

LEARNING OBJECTIVES:

- To understand the physical structure and behaviour of the earth as well as geomagnetic properties of rocks in the Earth's crust.
- To study the elastic behaviour in earth by applying various theories and hypothesis.
- To highlight the concept of solar system and behaviour of planets in this system.

UNIT –1: SOLAR SYSTEM

The earth and the solar system – Important physical parameters and properties of the planet earth; Stress and Strain, Wave and motion, Seismic waves. Travel time Tables and Velocity – Depth curves – Variation of Density within the Earth.

UNIT – 2: GRAVITATION

Rotation of the Earth - Gravitational attraction, Gravitational Theory, Measurements of Gravity, Gravity meters - Principles and method of measuring gravity - Gravity anomalies-Local and regional variations.

UNIT – 3: THERMAL HISTORY OF EARTH

Thermal history of the Earth. Temperature in the Primitive Earth and the Earth's surface and interior. Thermal conductivity. Generation of heat in the Earth. Heat flow measurements, methods and results.

UNIT – 4: ELASTIC PROPERTIES

Elastic constants and Elastic process in the earth. Earth's free rotation. Latitude variation. Tides of the Solid earth. Numerical values of Love's numbers. Rigidity of the Earth. Bulk modules in the earth. Poisson's ratio in the Earth, Young's modulus and Lame's constant.

UNIT – 5: GEOMAGNETISM AND PALAEOMAGNETISM

Geomagnetism and palaeomagnetism-Earth's magnetic field. Origin-Theory of earth's magnetic field. Magneto hydrodymics of the Earth. Magnetic reversals. Polar wandering. Tectonic movements and its relation to palaeomagnetism - Measurement of magnetic properties of rocks.

TEXT BOOKS:

1. A.H. Cook, Physics of the Earth and planets, Macmillan, 1973.
2. J. A. Jacobs, R. D. Russel and J. T. Wilson, Physics and Geology, 1974.
3. A.S. Eve and Keys, D. A, Applied Geophysics, Cambridge University, 1954.

SUPPLEMENTARY READING:

1. Gutenberg, Physics of the Earth's Interior, International Geophysics Series, Vol.1 Academic Press, 1959.
2. P.J. Wyllie, International Student Edition., The dynamic Earth, John Wiley and sons, 1971.
3. C.M.R. Fowler, The Solid Earth, An Introduction to Global Geophysics, Cambridge University press, 1990.
4. Alan Cox, Geomagnetic Reversals and Plate Tectonics, Freeman and company, 1973.

COURSE OUTCOMES (COs):

By the end of the semester, the students will be able to

CO1 : Think and analyse the concept of the Earth and its properties.
CO2 : Accumulate the various concepts proposed by theories and laws.
CO3 : Enlighten the concept solar system.
CO4: Acquire basic knowledge about geomagnetism and palaeomagnetism.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓

CO2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓

SEMESTER - II	**19PHYE205.3 - ENERGY PHYSICS**	**Credit:3** **Hours:3**

LEARNING OBJECTIVES:

- To create an awareness among the students regarding the forms of energy and the availability of their resources
- To educate regarding the utilization and conservation of energy
- To impart a knowledge about the Sustainable forms of energy

UNIT– 1: CONVENTIONAL ENERGY SOURCES

Energy sources and their availability – Various forms of energy – Renewable and conventional energy systems – Comparison – Coal, oil and natural gas.

UNIT – 2: SOLAR ENERGY

Solar Energy - Thermal application and solar radiation – Energy alternatives – Devices for thermal collection and storage – Thermal applications – Water heating – Space heating – Power generation – Instruments for measuring solar radiation and sun shine.

UNIT – 3: THERMAL ENERGY STORAGE

General characteristics - Definitions - Methods of classifications - Thermal energy storage - Sensible heat storage - Liquids - Solids – Latent heat storage - Thermal chemical storage.

UNIT – 4: PHOTO CONVERSION

Photovoltaic conversion - Principle and working of solar cells - Conversion efficiency - Single crystal and Polycrystalline silicon - Cadmium sulphide - Cadmium telluride.

UNIT – 5: SUSTAINABLE FORMS OF ENERGY

Reserves of Energy Resources – Environmental aspects of energy extraction, conversion and utilization – challenges associated with the non-sustainable energy sources with regard to future Supply and the environment

Hydrogen: principle of operation and system components-comparisons among energy uses, resources, and technologies-technical and economic challenges in the integration of sustainable energy form-potential solutions and application.

TEXT BOOKS:

1. P. Sukhatme, Solar energy, Tata McGraw-Hill, (Second edition), 2008.
2. D.P. Kothari, K.C. Singal and Rakesh Ranjan,Renewable energy sources and emerging Technologies, Prentice Hall of India, 2008.

3. S.A. Abbasi and Nasema Abbasi, Renewable Energy sources and their Environmental Impact, PHI Learning Pvt. Ltd., 2008.
4. M.P.Agarwal, Solar Energy, S.Chand & Co, 1983.
5. S.P.Sukhatme, Solar Energy, TMH, 1996.
6. G.D.Rai, Non-conventional Energy sources, Khauna Publication, 2004.

SUPPLEMENTARY READING:

1. John Twidell & Tony Weir, Renewable Energy Resources Taylor & Francis Group, 2006.
2. Kreith and Kreider, Principles of Solar Engineering, McGraw Hill Pub, 1978.
3. A.B.Meinel and A.P.Meinal, Applied Solar Energy, 1976.

COURSE OUTCOMES (COs):

By the end of the course, the student will be able to

CO1: Be aware of various forms of energy and the effective utilization of their resources.
CO2: Be exposed to the practical usage of solar energy.
CO3: Be exposed to the practical usage of thermal energy.
CO4: Acquire an in depth knowledge about the sustainable forms of energy.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓

SEMESTER - III	**19PHYE305.1 – INSTRUMENTATION**	**Credit : 3** **Hour : 4**

LEARNING OBJECTIVES:

- To understand the types of transducer for a particular measurement.
- To develop knowledge in digital, analytical and biomedical instruments for different applications.
- To know the functioning of medical imaging instruments.

UNIT – 1: TRANSDUCERS

Basic functional elements of measuring system-Transducers: Definition-Parts-Classification-Types of primary sensing element.

LVDT: Principle –Working –Measurement of displacement.

Electrical Strain Gauge: Principle-Theory-Types-Working -Measurement of Force (or) Pressure.

Capacitive Transducers: Principle-Types-Working-Measurement of linear and angular displacement.

Thermistor: Principle-Working-Measurement of temperature.

Piezo electric transducers: Principle, theory and working of piezo electric crystals.

UNIT – 2: DIGITAL INSTRUMENTATION

Principle, block diagram and working of: Digital Multimeter, Digital Frequency counter, Digital pH meter, Digital conductivity meter, Digital storage Oscilloscope and Q-meter.

UNIT – 3: ANALYTICAL INSTRUMENTATION

Principle, working, Instrumentation and applications of UV-Vis Spectrophotometer, ICP-AES, (Inductively coupled plasma-Atomic emission spectroscopy), SEM (Scanning Electron Microscope) and AFM (Atomic Force Microscopy).

UNIT – 4: BIO-MEDICAL INSTRUMENTATION

Orgin of Bio–potentials: Measurements- Resting and action potentials-Characteristics of resting potential-Bio electric potentials-Types of bioelectric signal and their characteristics.

Components of the Bio-medical instrument system-Electrodes: Equivalent circuit-Theory -Types.

Principle, block diagram and functioning of ECG, EEG and EMG.

UNIT – 5: MEDICAL IMAGING INSTRUMENTATION

Magnetic Resonance Imaging: Principle-Magnetic resonance phenomena-Magnetic resonance imaging-Imaging process-Instrumentation.

Ultrasonic Imaging System: Principle-Construction of an ultrasonic transducer-Ultrasonic propagation through tissues-Display-A mode- B mode- M mode-TM mode-Doppler mode-Recording devices.

Computed Tomography: Principle-CAT scanning-Instrumentation-Contrast scale-Scanning components.

TEXT BOOKS:

1. A.K.Sawhney, Electrical and Electronics Measurement and Instrumentation, Dhanpath Rai and Co., Pvt., Ltd., 2000.
2. Dr.Rajendra Prasad, Electronic Measurements and Instrumentation, Khanna Publishers, 2002
3. M.Arumugam, Biomedical Instrumentation, Anuradha Publishers, 2001.
4. V.Ramasamy, Instrumentation, Swami Publications, 2005.

SUPPLEMENTARY READING:

1. Willard.D. Merrit et.al.,Instrumental methods of analysis, CBS Publishers, 2004.
2. Gurdeep Chatwal and Sham Anand, Instrumental methods of analysis, Himalaya Publishers, 2003.
3. R.S.Khandpur, Hand Book of Biomedical Instrumentation, TMH, 2007.
4. B.C.Nakra and K.K.Chawdry, Instrumentation, Measurement and Analysis, TMH, 2004.
5. Albert D.Helfrock and William D Cooper, Modern Electronic Instrumentation and Measurement Techniques, Printice Hall of India, 2000.
6. S.K.Venkata Ram,Bio Medical Electronics and Instrumentation, Galgotia Publications Pvt. Ltd., 2001.

COURSE OUTCOMES (COs):

By the end of the Course, the students will be able to

CO1: Select the types of transducer for a particular measurement.
CO2: Test and use the digital instruments for different applications.
CO3: Understand the various analytical and biomedical instrumentation and their uses.
CO4: Know the functioning of medical imaging instruments.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓				✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓				✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓

SEMESTER - III	**19PHYE305.2- BIO-MEDICAL INSTRUMENTATION**	**Credit:3** **Hours:3**

LEARNING OBJECTIVES:

- To gain the knowledge about the bio medical instruments used for measuring bio-electric potentials and the electrodes used for sensing the bio potentials.
- To understand the working principles of imaging equipments and bio medical instruments used for determining the physiological parameters.
- To update the knowledge of various lasers used for medical applications for the students.

UNIT – 1: BIO-ELECTRIC POTENTIALS

Resting and action potentials – Propagation of action potentials – Bioelectric potentials-Electrocardiogram (ECG) – Electroencephalogram (EEG) –Electromyogram (EMG) – Electroretinography(ERG) - Electrooculography (EOG).

UNIT – 2: BIO-POTENTIAL ELECTRODES

Biopotential Electrodes – Types of Electrodes -Microelectrodes – Body surface electrodes – Depth and Needle electrodes- Chemical electrodes –Distortion in measured bioelectric signals using electrodes-Electrode paste

UNIT – 3: IMAGING EQUIPMENTS

Ultrasonic Imaging-Reflection-Scattering-A mode display-B mode display-T-M mode display-Ultrasonic imaging instrumentation-Biomedical applications- Magnetic Resonance Imaging (MRI)-Principle-Instrumentation-Advantages of MRI over other medical imaging techniques- Thermography-Endoscopy

UNIT – 4: MEASUREMENT OF PHYSIOLOGICAL PARAMETERS

Blood Pressure Measurement-Introduction-Direct Measurement using Catheters-Advance of Direct Method-Indirect Method-Oscillometric measurement method-

Electromagnetic Blood Flow Meters-Ultrasonic Blood Flow Meter-transit time method-Doppler effect based ultrasonic blood flow meter-laser Doppler Blood Flow Meter-NMR Blood Flow Meter

UNIT – 5: LASER IN MEDICINE

Introduction- Characteristics of laser light- Generation of laser- Components of laser-Types of laser-Nd-YAG laser-Helium-Neon laser - CO_2 laser- Semiconductor laser- Applications of laser in Medical field.

TEXT BOOKS:

1. T.Rajalakshmi, Bio Medical Instrumentation, Sams Publishers, First Edition, 2008.
2. M.Arumugam, Biomedical Instrumentation, Anuradha Agencies, Fourth reprint, 2000.
3. R.S. Khandpur, Hand book of Biomedical Instrumentation, Tata McGraw Hill, 2007.

SUPPLEMENTARY READING:

1. Robert B Northrop, Introduction to Biomedical Instrumentation and Measurements, LLCCRC Press, Taylor & Francis Group, 2 nd Ed, (2005).
2. R.S. Khandpur, Hand Book of Bio medical Instrumentation, Access Eng. 3 rd Edn., (2016).
3. Dominique Placko, Fundamentals of Instrumentation and Measurement, ISTE Ltd., (2007).

COURSE OUTCOMES (COs):

By the end of the course, the student will be able to

CO1: Understand the importance of bio medical instruments and accuracy of the measured physical parameters and their practical implementation in the medical field.

CO2: Understand experimentally recording data, its inference to diagnose the diseases.

CO3: Understand various techniques and its relevance in various defects in the body parts.

CO4: Solve the health issues from the bio medical instruments and applicability in physics concepts may give the clear idea about the health issues.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓				✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓				✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓

SEMESTER - III	**19PHYE305.3 - PETRO PHYSICS**	**Credit:3** **Hours:3**

LEARNING OBJECTIVES:

- To understand the various magnetites and behaviour of the remenance properties.
- To study the geomagnetic elements of the earth and various magnetometer instruments.
- To understand the classification and properties of of rock forming minerals
- To highlight the concept of seismic waves and various dating methods.

UNIT – 1

Magneto crystalline anisotropy – Dipolar anisotropy – Single ion anisotropy – Anisotropic exchange – Constants. Magnetic properties of mineral systems – Solid- Solid – Solution of oxides of iron – magnetite, haematite magnemites, titano magnetites, titono magneites, haematite – illmenite solid solution and pyrhotites – Intrinsic properties, magnetization process, weak field remanance.

Remanance properties- NRM, TRM, CRM, DRM, VRM, PRM – their mechanisms – Thermal demagnetization technique – partial TRM – additive law – Neel's theory of TRM. Primary and Secondary magnetization – Testing for stability of remanance.

UNIT – 2

Geomagnetic elements of the earth – Field variation and detection - The Magnetic observatory – mapping of secular variations. Diurnal variation of magnetic disturbances – initial susceptibility of rocks – single and multidomain cases – Curie point determination and its importance.

Laboratory and field instruments for magnetic measurements – Astatic magnetometer – spinner magnetometer – Fluxgate magnetometer, Proton procession magnetometer – Theory, practice and applications.

UNIT – 3

Classification of rock forming minerals – physical properties of minerals with special reference to optical properties – elementary details of a polarizing microscope and petrographic analysis.

Geophysical prospecting – different methods – Geophysical properties of rocks and minerals – Resistivity methods – Two current electrode method - different electrode layouts – measuring equipment – application to ground water survey.

UNIT – 4

Seismic waves – S waves & P waves – elastic, plastic behavior of rocks – modulus of elasticity in rocks – Time distance curves and the location of epicenters – Derivation properties from the velocities – the recent developments.

UNIT – 5

Geochronology – the geological time scale – archaeo-magnetic dating – Radio active methods of dating – Rubidium, Strontium method – Potassium Argon method – Thermo-luminescence dating and interpretation of data.

TEXT BOOKS:

1. RL. Singhal, Solid State Physics Kedarnath Ramnath & Co. Meerut.
2. A.J. Dekker, Solid State Physics, Prentice Hill.
3. Semana and Gupta and Sexana, Solid State Physics, Pragati Prakash, Meerut.
4. Eve and Keys, Applied Geophysics, Cambridge University Press.
5. W.O. Reilly, Rock and Mineral magnetism,Blackmoore.

SUPPLEMENTARY READING:

1. Howell, Introduction to Geophysics, McGraw Hill Book Co.
2. G.D. Garland, Introduction to Geophysics, Saunder's Book Co., 2^{nd} Edn.
3. T.H. Tarling, Principles and Applications of Paleomaguetism –, Chapmann and Hall.
4. Mc Elhinny, Paleomagnetism and Plate Tectonics,Cambridge University Press.
5. Dobrin, Introduction to Geophysical propecting, McGraw Hill Book Co.

COURSE OUTCOMES (COs):

By the end of the course, the student will be able to

CO1: Understand the various magnetites and behaviour of the remenance properties.
CO2: Study the geomagnetic elements of the earth and various magnetometer instruments.
CO3: Understand the classification and properties of of rock forming minerals
CO4: Highlight the concept of seismic waves and various dating methods.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓

SEMESTER - III	**19PHYE305.4 - MEDICAL PHYSICS**	**Credit:3** **Hours:3**

LEARNING OBJECTIVES:

- To gain the knowledge about the bio medical instruments used for measuring bio-electric potentials and the electrodes used for sensing the bio potentials.
- To understand the working principles of imaging equipments and bio medical instruments used for determining the physiological parameters.
- To update the knowledge of various nuclear medicine and biological effects of radiation.

Unit – 1: Bio-Electric Potentials

Resting and action potentials - Propagation of action potentials – Bioelectric potentials – Electrocardiogram (ECG) – electroencephalogram (EEG) – Electromyogram (EMG) – Electroetinography – Electrooculography (EOG).

Bio- potential Electrodes – Types of electrodes – Microelectrodes – Body surface electrodes – Depth and Needle electrodes – Chemical electrodes – Distortion in measured bioelectric signals using electrodes – Electrode paste.

Unit – 2: Digital X-ray imaging and Computed Tomography

Production of X-rays – Types of X-ray tubes – Generators – Interaction of X and Gamma rays with matter – Image formation and image quality – CR and DR – the image intensifier – fluoroscopy – Equipment for computed tomography scanning – Image reconstruction – Helical and multi-slice scanning – Image quality and artifacts – CT dose index.

Unit – 3: Imaging with Ultrasound and MRI

Piezoelectric effect – Interference – Different types of transducers – Modes of scanning – Image quality and artifacts – Doppler methods – Hemodynamic data – The spinning proton – the MR signal – Spin echo sequence – Spatial encoding – Other pulse sequences – functional MRI – Image quality and artifacts – Magnets and coils – Hazards and safe practice – Thermograpy – endoscopy.

Unit – 4: Physics of Nuclear Medicine and Biological effects of Radiation

Radioactivity - Radioactive transformation – Radiopharmaceuticals – Hot lab – Gamma camera – Planner imaging – tomography with radionuclide – PET scanner – Characteristics and quality assurance of images – Precautions necessary in handling open radioactive sources – Ionizing radiation interactions with tissues – Radiation dose and units – Effects of radiation – Principles of radiation protection – ICRP, BARC and AERB – eLORA – Practical aspects of radiation protection.

Unit – 5: Medical Imaging Instrumentation

Radiation therapy – Surgery – Chemotherapy – Hormone therapy – Immunotherpy and Radionuclide therapy – Begin and malignant disease – Methods of spread of malignant disease – Staging and grading systems, Treatment intent – Curative and Palliative – Teletherapy and Brachy therapy – Co-60 and other radioactive sources used in the treatment of cancer – Linear accelerator – Modern treatment techniques – Treatment planning – Non-Photon ionizing radiation treatments and challenges.

TEXT BOOKS:

1. T.Rajalakshmi, Bio Medical Instrumentation, First Edition, 2008.
2. M.Arumugam, Bio Medical Instrumentation, Anuradha Agencies, Fourth reprint, 2000.
3. R.S.Khandpur, Handbook of Biomedical Instrumentation, Tata McGraw Hill, 2007.

SUPPLEMENTARY READING:

1. Penelope Allsiy, Rpberts, Jerry R.Villiams, Saunders,Farr's Physics for Medical Imaging, Elsevier, Second Edition, 2008.
2. Fiaz M.Khan, The Physics of Radiation Therapy, 2006.
3. Ramesh Chandra, Nuclear Medicine Physics, , Lea and Febiger. 5^{th} Edition

COURSE OUTCOMES (COs):

By the end of the course, the student will be able to

CO1 :To gain the knowledge about the bio medical instruments used for measuring bio-electric potentials and the electrodes used for sensing the bio potentials.
CO2 :To understand the working principles of imaging equipments used for determining the physiological parameters.
CO3 :To understand the working principles of bio medical instruments used for determining the physiological parameters.
CO4 :To update the knowledge of various nuclear medicine and biological effects of radiation.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓				✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓				✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓

SEMESTER - III	19PHYE305.5 – BIOPHYSICS	Credit:3 Hours:3

LEARNING OBJECTIVES:

- To understand the applications of various microscopic tools in cell biology.
- To understand the fundamentals of macromolecular structure.
- To understand the analytical techniques in characterizing biomolecular interactions and its structure.

Unit – 1: CELL ORGANIZATION

Cell as the basic structural unit- Origin & organization of Prokaryotic and Eukaryotic cell-Cell size & shape- Fine structure of Prokaryotic & Eukaryotic cell organization (Bacteria, Cyanobacteria, plant & Animal cell)- Internal architecture of cells- cell organelles- compartment & assemblies membrane system- Ribosome- Polysomes- Lysosomes- Peroxisomes-Connection between cell & its environment- Extracellular Matrix.

Unit – 2: TOOLS IN CELL BIOLOGY

Light microscope- Resolving Power- Phase contrast microscope- Detection of small differences in refractive indices- Interference microscope-, Dark field microscope- Polarization microscope- Fluorescence microscope- Cytophotometry methods- Flowcytometry & cell sorting-Electron microscopy- specimen preparation- Scanning Electron Microscopy (SEM)-Transmission Electron Microscopy (TEM)-Applications.

Unit – 3: MACROMOLECULAR STRUCTURE

Nucleic acid structure: Chemical structure of the nucleic acid - Conformational possibilities of monomers and polymers- Double helix structure of DNA- Polymorphism of DNA-DNA nanostructures and the structure of transfer RNA.

Proteins structure: Amino acids and the primary structures of proteins – Secondary – Tertiary - Quaternary structure and virus structure.

Unit – 4: SEPERATION TECHNIQUES

Centrifugation**:** Principle of centrifugation –Analytical ultracentrifugation – Differential centrifugation – Density gradient centrifugation.

Chromatography**:** Principles of chromatography– Paper chromatography – Thin layer chromatography (TLC) – Gas liquid chromatography (GLC) – High performance liquid chromatography (HPLC).

Electrophoresis: Principles – Factors affecting the migration of substances – Supporting media in electrophoresis – Gel electrophoresis – Polyacrylamide gel electrophoresis (PAGE) – Sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE).

Unit – 5: OPTICAL & DIFFRACTION TECHNIQUES

Circular Dichroism and optical rotator dispersion-: Plane, circular and elliptical polarization of light- Absorption by oriented molecules- Dichroic ratio of proteins and nucleic acids- Circular dichroism (CD) - optical rotatory disperson (ORD) - Relation between CD and ORD- Application of ORD in conformation and interactions of biomolecules.

Crystallization of proteins- preparation of heavy metal derivatives- Patterson synthesis-isomorphous replacement methods- structure factors of centro-symmetric and non-centrosymmetric crystals- General remarks on Protein-Structure determination from X-ray diffraction data-Neutron diffraction-, Electron diffraction-, Synchrotron diffraction, Application in Biomolecular structural studies.

TEXT BOOKS:

1. M.A. Subramanian, Biophysics, MJP Publishers, 2005.
2. L.Veerakumari, Bioinstrumentation, MJP Publishers, 2006.
3. A.C. Deb, Fundamentals of Biochemistry, New central book agency, 2011.

SUPPLEMENTARY READING:

1. Geoffrey M.Cooper, The Cell: A Molecular Approach, ASM Press, 2013.
2. Vasantha Pattabhi, N. Gautham, Biophysics, Narosa Publishing, 2009.
3. P.S. Mishra Biophysics, VK Enterprises, 2010.

COURSE OUTCOMES (COs):

By the end of the course, the students will be able to

CO1: Have in-depth knowledge of the structure of cells and the macromolecular structure.

CO2: Understand the basic principles of the various microscopic techniques presented in the course, their advantages and limitations.

CO3: Provide an introduction to various separation techniques that are used in biological samples.

CO4: Understand the different processes of optical and diffraction techniques.

MAPPING WITH PROGRAMME OUTCOMES (POs) and PROGRAMME SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓	✓	✓	✓						✓	✓		✓	✓	✓	✓	✓

CO2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓