B.S. Abdur Rahman ™
Crescent
Institute of Science & Technology
Deemed to be University u/s 3 of the UGC Act, 1956

Regulations 2022
Curriculum and Syllabi
(Updated upto April 2023, as per 20th Academic Council)

M.Sc. (Physics)

B.S. Abdur Rahman ™ Crescent Institute of Science & Technology
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REGULATIONS 2022

CURRICULUM AND SYLLABI

(Updated upto April 2023, as per 20th Academic Council)

M.SC. PHYSICS

VISION AND MISSION OF THE INSTITUTION

VISION

B.S. Abdur Rahman Crescent Institute of Science and Technology aspires to be a leader in Education, Training and Research in multidisciplinary areas of importance and to play a vital role in the Socio-Economic progress of the Country in a sustainable manner.

MISSION

- To blossom into an internationally renowned Institute.
- To empower the youth through quality and value-based education.
- To promote professional leadership and entrepreneurship.
- To achieve excellence in all its endeavors to face global challenges.
- To provide excellent teaching and research ambience.
- To network with global Institutions of Excellence, Business, Industry and Research Organizations.
- To contribute to the knowledge base through Scientific enquiry, Applied Research and Innovation.

VISION AND MISSION OF DEPARTMENT OF PHYSICS

VISION

To be a leader in providing quality higher education through well designed programs and undertake research in Physical Sciences and related interdisciplinary areas.

MISSION

- To provide quality education in the field of Physical Sciences through well designed programs.
- To provide necessary knowledge in Physical Sciences required for all programs in science and engineering.
- To offer quality programs in advanced and applied physical sciences.
- To undertake fundamental, applied and interdisciplinary research in emerging areas.

PROGRAMME EDUCATIONAL OBJECTIVES AND OUTCOMES

M.Sc (Physics)

Programme Educational Objectives (PEOs)

- To identify, formulate, analyze and optimize variety of problems related to various fields of Physics through basic knowledge and to apply the skills and knowledge acquired during the UG studies.
- To acquire knowledge of fundamental laws and principles in wide areas of Physics along with their applications so as to develop strong student competencies in Physics and its applications in a technology-rich, interactive environment.
- To prepare for the successful pursuit of Post Graduate studies and shall have abilities to engage in life-long learning in various fields of Physics and General Science.
- To understand the challenges of a dynamically and globalised changing world adapting their skills through continuous learning and self-improvement.
- To work effectively in bringing interdisciplinary ideas related to diverse environmental skills to excel in technical careers and thrive in Post Graduate and research studies using scientific principles and applications of Physical Science.
- To become effective researcher who will be able to provide lucid summation of the scientific literature on a given topic of study.
- To develop their skills to plan, execute and report the results of extended computational techniques, experimental and theoretical Physics based projects in a research environment.
- To inculcate the sense of ethics, professionalism and effective communication skills amongst graduates improve their workplaces, communities and the society through professional and personal responsibilities and activities of their work.
- To prepare the students to successfully compete for employment and to offer a wide range of experience in research methods, data analysis to meet the industrial needs.

Programme Outcomes (POs)

After the completion of PG programme, graduates will be able to

- Design and conduct experiments, as well as to analyze and interpret data.
- Function on interdisciplinary teams with professional and ethical responsibility.
- Use the modern techniques, skills and sophisticated equipment necessary for research.
- Apply knowledge and skill in the design and development of Electronics circuits to cater to the needs of Electronic Industry.
- Become professionally trained in the area of optical communication, lasers, nonlinear circuits, materials development and characterization including nanomaterials.
- Demonstrate highest standards of actuarial ethical conduct and professional actuarial behavior, critical, interpersonal and communication skills as well as a commitment to life-long learning.
- Successfully compete for employment in the field of Teaching, Research and Industries.

B.S. ABDUR RAHMAN CRESCENT INSTITUTE OF SCIENCE AND TECHNOLOGY, CHENNAI – 600 048.

REGULATIONS 2022

M.Tech. / MCA / M.Sc. / M.Com. / M.A. DEGREE PROGRAMMES

(Under Choice Based Credit System)

1.0 PRELIMINARY DEFINITIONS AND NOMENCLATURE

In these Regulations, unless the context otherwise requires:

i) **"Programme"** means post graduate degree programme (M.Tech. / MCA / M.Sc. / M.Com. / M.A.)

ii) **"Branch"** means specialization or discipline of programme like M.Tech. in Structural Engineering, Food Biotechnology etc., M.Sc. in Physics, Chemistry, Actuarial Science, Biotechnology etc.

iii) **"Course"** means a theory / practical / laboratory integrated theory / mini project / seminar / internship / project and any other subject that is normally studied in a semester like Advanced Concrete Technology, Electro Optic Systems, Financial Reporting and Accounting, Analytical Chemistry, etc.

iv) **"Institution"** means B.S. Abdur Rahman Crescent Institute of Science and Technology.

v) **"Academic Council"** means the Academic Council, which is the apex body on all academic matters of this Institute.

vi) **"Dean (Academic Affairs)"** means the Dean (Academic Affairs) of the Institution who is responsible for the implementation of relevant rules and regulations for all the academic activities.

vii) **"Dean (Student Affairs**)" means the Dean (Students Affairs) of the Institution who is responsible for activities related to student welfare and discipline in the campus.

viii) **"Controller of Examinations"** means the Controller of Examinations of the Institution who is responsible for the conduct of examinations and declaration of results.

ix) **"Dean of the School"** means the Dean of the School of the department concerned.

x) **"Head of the Department"** means the Head of the Department concerned.

2.0 PROGRAMMES OFFERED AND ADMISSION REQUIREMENTS

2.1 Programmes Offered

The various programmes and their mode of study are as follows:

Degree	Mode of Study
M.Tech.	Full Time
MCA	
M.Sc.	
M.Com.	
M.A.	

2.2 ADMISSION REQUIREMENTS

2.2.1 Students for admission to the first semester of the Master's Degree Programme shall be required to have passed the appropriate degree examination as specified in the clause 3.2 [Eligible entry qualifications for admission to programmes] of this Institution or any other University or authority accepted by this Institution.

2.2.2 The other conditions for admission such as class obtained, number of attempts in the qualifying examination and physical fitness will be as prescribed by the Institution from time to time.

3.0 DURATION, ELIGIBILITY AND STRUCTURE OF THE PROGRAMME

3.1. The minimum and maximum period for completion of the programmes are given below:

Programme	Min. No. of Semesters	Max. No. of Semesters
M.Tech.	4	8
MCA	4	8
M.Sc.	4	8
M.Com.	4	8
M.A.	4	8

3.1.1 Each academic semester shall normally comprise of 90 working days. Semester end examinations shall follow within 10 days of the last Instructional day.

3.1.2 Medium of instruction, examinations and project report shall be in English.

3.2 ELIGIBLE ENTRY QUALIFICATIONS FOR ADMISSION TO PROGRAMMES

Sl. No.	Name of the Department	Programmes offered	Eligibility for Admission in M.Tech. / MCA / M.Sc. / M.Com. / MA Programmes
1.	Aeronautical Engineering	M.Tech. (Avionics)	B.E. / B.Tech. in Aeronautical Engineering / Aerospace Engineering / Mechanical Engineering / Mechatronics / EEE / ECE / EIE / or Equivalent degree in relevant field.
2.	Civil Engineering	M.Tech. (Structural Engineering)	B.E. / B.Tech. in Civil Engineering / Structural Engineering or Equivalent degree in relevant field.
		M. Tech. (Construction Engineering and Project Management)	B.E. / B.Tech. in Civil Engineering / Structural Engineering / B.Arch. or Equivalent degree in relevant field.
3.	Mechanical Engineering	M.Tech. (CAD/CAM)	B.E. / B.Tech. in Mechanical / Automobile / Manufacturing / Production / Industrial / Mechatronics / Metallurgy / Aerospace / Aeronautical / Material Science / Polymer / Plastics / Marine Engineering or Equivalent degree in relevant field.
4.	Electrical and Electronics Engineering	M.Tech. (Power Systems Engineering)	B.E. / B.Tech. in EEE / ECE / EIE / ICE / Electronics / Instrumentation Engineering or Equivalent degree in relevant field.
5.	Electronics and Communication Engineering	M.Tech. (VLSI and Embedded Systems)	B.E. / B.Tech. in ECE / EIE / ICE / EEE / IT or Equivalent degree in relevant field.
6.	Computer Science and Engineering	M.Tech. (Computer Science and Engineering)	B.E. / B.Tech. in CSE / IT / ECE / EEE / EIE / ICE / Electronics Engineering / MCA or Equivalent degree in relevant field.

Sl. No.	Name of the Department	Programmes offered	Eligibility for Admission in M.Tech. / MCA / M.Sc. / M.Com. / MA Programmes
		M.Tech. (Artificial Intelligence and Data Science)	B.E. / B.Tech. in CSE / IT / ECE / EEE / EIE / ICE / Electronics Engineering / MCA or Equivalent degree in relevant field.
7.	Information Technology	M.Tech. (Information Technology)	B.E. / B.Tech. in IT / CSE / ECE / EEE / EIE / ICE / Electronics Engineering / MCA or Equivalent degree in relevant field.
8.	Computer Applications	MCA	BCA / B.Sc. Computer Science / B.E. / B.Tech. / B.Sc. Mathematics, B.Sc. Physics / Chemistry / B.Com. / BBA / B.A. with Mathematics at graduation level or at 10 + 2level or equivalent degree in relevant field.
9.	Mathematics	M.Sc. (Actuarial Science)	Any under graduate degree with Mathematics / Statistics as one of the subjects of study at 10 + 2 level.
10.	Physics	M.Sc.(Physics)	B.Sc. in Physics / Applied Science / Electronics /Electronics Science / Electronics & Instrumentation or Equivalent degree in relevant field.
11.	Chemistry	M.Sc.(Chemistry)	B.Sc. in Chemistry / Applied Science or Equivalent degree in relevant field.
12.	Life Sciences	M.Sc. Biochemistry & Molecular Biology	B.Sc. in Biotechnology / Biochemistry / Botany / Zoology / Microbiology / Molecular Biology / Genetics or Equivalent degree in relevant field.
		M.Sc. Biotechnology	B.Sc. in Biotechnology / Biochemistry / Botany / Zoology / Microbiology / Molecular Biology / Genetics or Equivalent degree in relevant field.
		M.Sc. Microbiology	B.Sc.in Biotechnology / Biochemistry / Botany / Zoology / Microbiology / Molecular Biology / Genetics or Equivalent degree in relevant field.
		M.Tech. Biotechnology	B.Tech. / B.E. in Biotechnology or Equivalent degree in relevant field.

Sl. No.	Name of the Department	Programmes offered	Eligibility for Admission in M.Tech. / MCA / M.Sc. / M.Com. / MA Programmes
		M.Tech. Food Biotechnology	B.E. / B.Tech. in Biotechnology / Food Biotechnology / Chemical Engineering / Biochemical Engineering / Industrial Biotechnology or Equivalent degree in relevant field.
13.	Commerce	M.Com	B.Com. / BBA
14.	Arabic and Islamic Studies	M.A. Islamic Studies	B.A. in Islamic Studies / Arabic (or) Afzal-ul-Ulama (or) Any under graduate degree with Part 1 Arabic (or) Any under graduate degree with Aalim Sanad / Diploma / Certificate in Arabic or Islamic Studies.

3.3. STRUCTURE OF THE PROGRAMME

3.3.1 The PG. programmes consist of the following components as prescribed in the respective curriculum:

i. Core courses
ii. Elective courses
iii. Laboratory integrated theory courses
iv. Project work
v. Laboratory courses
vi. Open elective courses
vii. Seminar
viii. Mini Project
ix. Industry Internship
x. MOOC courses (NPTEL-Swayam, Coursera etc.)
xi. Value added courses

3.3.2 The curriculum and syllabi of all programmes shall be approved by the Academic Council of this Institution.

3.3.3 For the award of the degree, the student has to earn a minimum total credits specified in the curriculum of the respective specialization of the programme.

3.3.4 The curriculum of programmes shall be so designed that the minimum prescribed credits required for the award of the degree shall be within the limits specified below:

Programme	Range of credits
M.Tech.	76 -80
MCA	86
M.Sc.	77 - 85
M.Com.	88
M.A.	72

3.3.5 Credits will be assigned to the courses for all programmes as given below:

- ❖ One credit for one lecture period per week or 15 periods of lecture per semester.
- ❖ One credit for one tutorial period per week or 15 periods per semester.
- ❖ One credit each for seminar/practical session/project of two or three periods per week or 30 periods per semester.
- ❖ One credit for 160 hours of industry internship per semester for all programmes (except M.Com.)
- ❖ Four credits for 160 hours of industry internship per semester for M.Com.

3.3.6 The number of credits the student shall enroll in a non-project semester and project semester is as specified below to facilitate implementation of Choice Based Credit System.

Programme	Non-project semester	Project semester
M.Tech.	9 to 32	18 to 26
MCA	9 to 32	18 to 26
M.Sc.	9 to 32	10 to 26
M.Com.	9 to 32	16 to 28
M.A.	9 to 32	NA

3.3.7 The student may choose a course prescribed in the curriculum from any department offering that course without affecting regular

class schedule. The attendance will be maintained course wise only.

3.3.8 The students shall choose the electives from the curriculum with the approval of the Head of the Department / Dean of School.

3.3.9 Apart from the various elective courses listed in the curriculum for each specialization of programme, the student can choose a maximum of two electives from any other similar programmes across departments, aliter to open electives, during the entire period of study, with approval of Head of the department offering the course and parent department.

3.4. ONLINE COURSES

3.4.1 Students are permitted to undergo department approved online courses under SWAYAM up to 40% of credits of courses in a semester excluding project semester (in case of M.Tech. M.Sc. & MCA programmes) with the recommendation of the Head of the Department / Dean of School and with the prior approval of Dean Academic Affairs during his/ her period of study. The credits earned through online courses shall be transferred following the due approval procedures. The online courses can be considered in lieu of core courses and elective courses.

3.4.2 Students shall undergo project related online course on their own with the mentoring of the project supervisor.

3.5 PROJECT WORK

3.5.1 Project work shall be carried out by the student under the supervision of a faculty member in the department with similar specialization.

3.5.2 A student may however, in certain cases, be permitted to work for the project in an Industry / Research organization, with the approval of the Head of the Department/ Dean of School. In such cases, the project work shall be jointly supervised by a faculty of the Department and an Engineer / Scientist / Competent authority from the organization and the student shall be instructed to meet the faculty periodically and to attend the review meetings for evaluating the progress.

3.5.3 The timeline for submission of final project report / dissertation is within 30 calendar days from the last instructional day of the semester in which project is done.

3.5.4 If a student does not comply with the submission of project report / dissertation on or before the specified timeline he / she is deemed to have not completed the project work and shall re-register in the subsequent semester.

4.0 CLASS ADVISOR AND FACULTY ADVISOR

4.1 CLASS ADVISOR

A faculty member shall be nominated by the HOD/ Dean of School as Class Advisor for the class throughout their period of study.

The class advisor shall be responsible for maintaining the academic, curricular and co-curricular records of students of the class throughout their period of study.

4.2 FACULTY ADVISOR

To help the students in planning their courses of study and for general counseling, the Head of the Department / Dean of School of the students shall attach a maximum of 20 students to a faculty member of the department who shall function as faculty advisor for the students throughout their period of study. Such faculty advisor shall guide the students in taking up the elective courses for registration and enrolment in every semester and also offer advice to the students on academic and related personal matters.

5.0 COURSE COMMITTEE

5.1 Each common theory / laboratory course offered to more than one group of students shall have a “Course Committee” comprising all the teachers handling the common course with one of them nominated as course coordinator. The nomination of the course coordinator shall be made by the Head of the Department / Dean (Academic Affairs) depending upon whether all the teachers handling the common course belong to a single department or from several departments. The Course Committee shall meet as often as possible to prepare a common question paper, scheme

of evaluation and ensure uniform evaluation of the assessment tests and semester end examination.

6.0 CLASS COMMITTEE

6.1 A class committee comprising faculty members handling the classes, student representatives and a senior faculty member not handling the courses as chairman will be constituted in every semester:

6.2 The composition of the class committee will be as follows:

i) One senior faculty member preferably not handling courses for the concerned semester, appointed as chairman by the Head of the Department
ii) Faculty members of all courses of the semester
iii) All the students of the class
iv) Faculty advisor and class advisor
v) Head of the Department – Ex officio member

6.3 The class committee shall meet at least three times during the semester. The first meeting shall be held within two weeks from the date of commencement of classes, in which the nature of continuous assessment for various courses and the weightages for each component of assessment shall be decided for the first and second assessment. The second meeting shall be held within a week after the date of first assessment report, to review the students' performance and for follow up action.

6.4 During these two meetings the student members, shall meaningfully interact and express opinions and suggestions to improve the effectiveness of the teaching-learning process, curriculum and syllabi of courses.

6.5 The third meeting of the class committee, excluding the student members, shall meet within 5 days from the last day of the semester end examination to analyze the performance of the students in all the components of assessments and decide their grades in each course. The grades for a common course shall be decided by the concerned course committee and shall be

presented to the class committee(s) by the concerned course coordinator.

7.0 REGISTRATION AND ENROLLMENT

7.1 The students of first semester shall register and enroll at the time of admission by paying the prescribed fees. For the subsequent semesters registration for the courses shall be done by the student one week before the last working day of the previous semester.

7.2 Change of a Course

A student can change an enrolled course within 10 working days from the commencement of the course, with the approval of the Dean (Academic Affairs), on the recommendation of the Head of the Department of the student.

7.3 Withdrawal from a Course

A student can withdraw from an enrolled course at any time before the first continuous assessment test for genuine reasons, with the approval of the Dean (Academic Affairs), on the recommendation of the Head of the Department of the student.

7.4 A student can enroll for a maximum of 32 credits during a semester including Redo / Predo courses.

8.0 BREAK OF STUDY FROM PROGRAMME

8.1 A student may be allowed / enforced to take a break of study for two semesters from the programme with the approval of Dean (Academic Affairs) for the following reasons:

8.1.1 Medical or other valid grounds

8.1.2 Award of 'I' grade in all the courses in a semester due to lack of attendance

8.1.3 Debarred due to any act of indiscipline

8.2 The total duration for completion of the programme shall not exceed the prescribed maximum number of semesters (vide clause 3.1).

8.3 A student who has availed a break of study in the current semester (odd/even) can rejoin only in the subsequent corresponding

(odd/even) semester in the next academic year on approval from the Dean (Academic affairs).

8.4 During the break of study, the student shall not be allowed to attend any regular classes or participate in any activities of the Institution. However, he / she shall be permitted to enroll for the 'I' grade courses and appear for the arrear examinations.

9.0 MINIMUM REQUIREMENTS TO REGISTER FOR PROJECT WORK

9.1 A student is permitted to register for project semester, if he/she has earned the minimum number of credits specified below:

Programme	Minimum no. of credits to be earned to enroll for project semester
M.Tech.	18
MCA	22
M.Sc.	18
M.Com	NA
M.A.	NA

9.2 If the student has not earned minimum number of credits specified, he/she has to earn the required credits, at least to the extent of minimum credits specified in clause 9.1 and then register for the project semester.

10.0 ATTENDANCE REQUIREMENT AND SEMESTER / COURSE REPETITION

10.1 A student shall earn 100% attendance in the contact periods of every course, subject to a maximum relaxation of 25% to become eligible to appear for the semester end examination in that course, failing which the student shall be awarded "I" grade in that course.

10.2 The faculty member of each course shall cumulate the attendance details for the semester and furnish the names of the students who have not earned the required attendance in the concerned course to the class advisor. The class advisor shall consolidate and furnish the list of students who have earned less than 75% attendance, in various courses, to the Dean (Academic Affairs) through the Head

of the Department / Dean of the School. Thereupon, the Dean (Academic Affairs) shall officially notify the names of such students prevented from writing the semester end examination in each course.

10.3 If a student secures attendance between 65% and less than 75% in any course in a semester, due to medical reasons (hospitalization / accident / specific illness) or due to participation in the institution approved events, the student shall be given exemption from the prescribed attendance requirement and the student shall be permitted to appear for the semester end examination of that course. In all such cases, the students shall submit the required documents immediately after joining the classes to the class advisor, which shall be approved by the Head of the Department / Dean of the School. The Vice Chancellor, based on the recommendation of the Dean (Academic Affairs) may approve the condonation of attendance.

10.4 A student who has obtained an “I” grade in all the courses in a semester is not permitted to move to the next higher semester. Such students shall repeat all the courses of the semester in the subsequent academic year. However, he / she is permitted to redo the courses awarded with 'I' grade / arrear in previous semesters. They shall also be permitted to write arrear examinations by paying the prescribed fee.

10.5 The student awarded “I” grade, shall enroll and repeat the course when it is offered next. In case of “I” grade in an elective course either the same elective course may be repeated or a new elective course may be taken with the approval of the Head of the Department / Dean of the School.

10.6 A student who is awarded “U” grade in a course shall have the option to either write the semester end arrear examination at the end of the subsequent semesters, or to redo the course when the course is offered by the department. Marks scored in the continuous assessment in the redo course shall be considered for grading along with the marks scored in the semester end (redo) examination. If any student obtains “U” grade in the redo course,

the marks scored in the continuous assessment test (redo) for that course shall be considered as internal mark for further appearance of arrear examination.

10.7 If a student with "U" grade, who prefers to redo any particular course, fails to earn the minimum 75% attendance while doing that course, then he / she is not permitted to write the semester end examination and his / her earlier "U" grade and continuous assessment marks shall continue.

11.0 REDO COURSES

11.1 A student can register for a maximum of two redo courses per semester without affecting the regular semester classes, whenever such courses are offered by the department oncerned, based on the availability of faculty members, and subject to a specified minimum number of students registering for each of such courses.

11.2 The number of contact hours and the assessment procedure for any redo course shall be the same as regular courses, except there is no provision for any substitute examination and withdrawal from a redo course.

12.0 ASSESSMENT PROCEDURE AND PERCENTAGE WEIGHTAGE OF MARKS

12.1 Every theory course shall have a total of three assessments during a semester as given below:

Assessments	Weightage of Marks
Continuous Assessment 1	25%
Continuous Assessment 2	25%
Semester End Examination	50%

12.2 Theory Course

Appearing for semester end theory examination for each course is mandatory and a student shall secure a minimum of 40% marks in

each course in semester end examination for the successful completion of the course.

12.3 Laboratory Course

Every practical course shall have 75% weightage for continuous assessments and 25% for semester end examination. However, a student shall have secured a minimum of 50% marks in the semester end practical examination for the award of pass grade.

12.4 Laboratory Integrated Theory Courses

For laboratory integrated theory courses, the theory and practical components shall be assessed separately for 100 marks each and consolidated by assigning a weightage of 75% for theory component and 25% for practical component. Grading shall be done for this consolidated mark. Assessment of theory components shall have a total of three assessments with two continuous assessments carrying 25% weightage each and semester end examination carrying 50% weightage. The student shall secure a separate minimum of 40% in the semester end theory examination. The evaluation of practical components shall be through continuous assessment.

12.5 The components of continuous assessment for theory/practical/laboratory integrated theory courses shall be finalized in the first class committee meeting.

12.6 Industry Internship

In the case of industry internship, the student shall submit a report, which shall be evaluated along with an oral examination by a committee of faculty members constituted by the Head of the Department. The student shall also submit an internship completion certificate issued by the industry / research / academic organisation. The weightage of marks for industry internship report and viva voce examination shall be 60% and 40% respectively.

12.7 Project Work

In the case of project work, a committee of faculty members constituted by the Head of the Department / Dean of the School will carry out three periodic reviews. Based on the project report submitted by the students, an oral examination (viva voce) shall be

conducted as semester end examination by an external examiner approved by the Controller of Examinations. The weightage for periodic reviews shall be 50%. Of the remaining 50%, 20% shall be for the project report and 30% for the viva voce examination.

12.8 The assessment of seminar course including its component and its weightage shall be decided by a committee of faculty members constituted by the Head of the Department. This committee shall ensure the conduct of assessment of components and award marks accordingly.

12.9 For the first attempt of the arrear theory examination, the internal assessment marks scored for a course during first appearance shall be used for grading along with the marks scored in the arrear examination. From the subsequent appearance onwards, full weightage shall be assigned to the marks scored in the semester end examination and the internal assessment marks secured during the course of study shall become invalid.

In case of laboratory integrated theory courses, after one regular and one arrear appearance, the internal mark of theory component is invalid and full weightage shall be assigned to the marks scored in the semester end examination for theory component. There shall be no arrear or improvement examination for lab components.

13.0 SUBSTITUTE EXAMINATIONS

13.1 A student who is absent, for genuine reasons, may be permitted to write a substitute examination for any one of the two continuous assessment tests of a course by paying the prescribed substitute examination fee. However, permission to take up a substitute examination will be given under exceptional circumstances, such as accidents, admission to a hospital due to illness, etc. by a committee constituted by the Head of the Department / Dean of School for that purpose. However, there is no substitute examination for semester end examination.

13.2 A student shall apply for substitute exam in the prescribed form to the Head of the Department / Dean of School within a week from the date of assessment test. However, the substitute

examination will be conducted only after the last working day of the semester and before the semester end examination.

14.0 SUPPLEMENTARY EXAMINATION

14.1 Final Year students can apply for supplementary examination for a maximum of three courses thus providing an opportunity to complete their degree programme. Likewise, students with less credit can also apply for supplementary examination for a maximum of three courses to enable them to earn minimum credits to move to higher semester. The students can apply for supplementary examination within three weeks of the declaration of results in both odd and even semesters.

15. PASSING, DECLARATION OF RESULTS AND GRADE SHEET

15.1 All assessments of a course shall be made on absolute marks basis. However, the Class Committee without the student members shall preferably meet within 5 days after the semester end examination and analyze the performance of students in all assessments of a course and award letter grades. The letter grades and the corresponding grade points are as follows:

Letter Grade	Grade Points
S	10
A	9
B	8
C	7
D	6
E	5
U	0
I	0

"I" denotes inadequate attendance and hence prevented from appearing for semester end examination

"U" denotes unsuccessful performance in the course.

15.2 A student who earns a minimum of five grade points ('E' grade) in a course is declared to have successfully completed the course. Such a course cannot be repeated by the student for improvement of grade.

15.3 The results, after awarding of grades, shall be signed by the Chairman of the Class Committee and Head of the Department/Dean of School and it shall be declared by the Controller of Examinations.

15.4 Within one week from the date of declaration of result, a student can apply for revaluation of his / her semester end theory examination answer scripts of one or more courses, on payment of prescribed fees to the Controller of Examinations. Subsequently the Head of the Department/ Dean of School offered the course shall constitute a revaluation committee consisting of Chairman of the Class Committee as convener, the faculty member of the course and a senior faculty member knowledgeable in that course as members. The committee shall meet within a week to re-evaluate the answer scripts and submit its report to the Controller of Examinations for consideration and decision.

15.5 After results are declared, grade sheets shall be issued to each student, which contains the following details: a) list of courses enrolled during the semester including redo courses / arrear courses, if any; b) grades scored; c) Grade Point Average (GPA) for the semester and d) Cumulative Grade Point Average (CGPA) of all courses enrolled from first semester onwards.

GPA is the ratio of the sum of the products of the number of credits of courses registered and the grade points corresponding to the grades scored in those courses, taken for all the courses, to the sum of the number of credits of all the courses in the semester.

If C_i, is the number of credits assigned for the i^{th} course and GP_i is the Grade Point in the i^{th} course

$$GPA = \frac{\sum_{i=1}^{n}(C_i)(GPi)}{\sum_{i=1}^{n} C_i}$$

Where n = number of courses

The Cumulative Grade Point Average (CGPA) is calculated in a similar manner, considering all the courses enrolled from first semester.

"I" grade is excluded for calculating GPA.

"U" and**"I"** grades are excluded for calculating CGPA.

The formula for the conversion of CGPA to equivalent percentage of marks is as follows:

Percentage Equivalent of Marks = CGPA X 10

15.6 After successful completion of the programme, the Degree shall be awarded upon fulfillment of curriculum requirements and classification based on CGPA as follows:

Classification	CGPA
First Class with Distinction	8.50 and above and passing all the courses in first appearance and completing the programme within the minimum prescribed period.
First Class	6.50 and above and completing the programme within a minimum prescribed period plus two semesters.
Second Class	Others

15.6.1 Eligibility for First Class with Distinction

- A student should not have obtained 'U' or 'I' grade in any course during his/her study
- A student should have completed the PG programme within the minimum prescribed period of study (except clause 8.1.1)

15.6.2 Eligibility for First Class

A student should have passed the examination in all the courses not more than two semesters beyond the minimum prescribed period of study (except clause 8.1.1)

15.6.3 The students who do not satisfy clause 15.6.1 and clause 15.6.2 shall be classified as second class.

15.6.4 The CGPA shall be rounded to two decimal places for the purpose of classification. The CGPA shall be considered up to three

decimal places for the purpose of comparison of performance of students and ranking.

16.0 DISCIPLINE

16.1 Every student is expected to observe discipline and decorum both inside and outside the campus and not to indulge in any activity which tends to affect the reputation of the Institution.

16.2 Any act of indiscipline of a student, reported to the Dean (Student Affairs), through the HOD / Dean shall be referred to a Discipline and Welfare Committee constituted by the Registrar for taking appropriate action.

17.0 ELIGIBILITY FOR THE AWARD OF THE MASTER'S DEGREE

17.1 A student shall be declared to be eligible for the award of the Master's Degree, if he/she has:

i. Successfully acquired the required credits as specified in the curriculum corresponding to his/her programme within the stipulated time.
ii. No disciplinary action is pending against him/her.
iii. Enrolled and completed at least one value added course.
iv. Enrollment in at least one MOOC / SWAYAM course (non-credit) before the final semester.

17.2 The award of the degree must have been approved by the Institute.

18.0 POWER TO MODIFY

Notwithstanding all that have been stated above, the Academic Council has the right to modify any of the above regulations from time to time.

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B.S. ABDUR RAHMAN CRESCENT INSTITUTE OF SCIENCE AND TECHNOLOGY

M.SC PHYSICS

CURRICULUM & SYLLABUS, REGULATIONS 2022

SEMESTER I

S. No.	Course Code	Course Title	L	T	P	C
1	PHE 6101	Classical Mechanics	4	0	0	4
2	PHE 6102	Mathematical Physics	3	1	0	4
3	PHE 6103	Electromagnetic Theory and Electrodynamics	3	0	0	3
5		Elective – I	2	0	2	3
6		Elective – II	2	0	2	3
7	PHE 6104	Analog, Digital Electronics and Instrumentation	4	0	0	4
8	PHE 6105	Advanced Electronics Laboratory	0	0	4	2
9	ENE 6182	Professional Communication	2	1	0	3
		Credits				**26**

SEMESTER II

S. No.	Course Code	Course Title	L	T	P	C
1	GEE 6202	Research Methodology and Intellectual Property Rights	3	0	0	3
2	PHE 6201	Quantum Mechanics	4	0	0	4
3	PHE 6202	Solid State Physics	3	0	0	3
4	PHE 6203	Atomic Physics and Molecular Spectroscopy	4	0	0	4
5		Elective – III	2	0	2	3
6		Elective – IV	3	0	0	3
7	PHE 6204	Materials Science Laboratory-I	0	0	4	2
8	PHE 6205	Optics and Thermal Laboratory	0	0	4	2
9		Value Added Course				-
		Credits				**24**

SEMESTER III

S. No.	Course Code	Course Title	L	T	P	C
1	PHE 7101	Laser and Non-linear Optics	3	0	0	3
2	PHE 7102	Thermodynamics and Statistical Physics	4	0	0	4
3	PHE 7103	Nuclear and Particle Physics	3	0	0	3
4		Elective –V	3	0	0	3
5		Elective –VI	3	0	0	3
		Open Elective Course	3	0	0	3
7	PHE 7104	Materials Science Laboratory-II	0	0	4	2
8	PHE 7105	Internship / Mini Project (During summer vacation after II Sem)	0	0	2	1
9.		MOOC (Related to project) SWAYAM / NPTEL				-
10	PHE 7201	Project Phase- I				2*
		Credits				**22**

SEMESTER IV

S. No.	Course Code	Course Title	L	T	P	C
1	PHE 7201	Project Phase II				10
		Credits	**(10 + 2)**			**12**

Overall Total Credits - 84

Industrial training will be undertaken during first year summer vacation for 30 days. The credit will be awarded in the 3rd Semester.

** Credits for project work phase I in III semester to be accounted along with project work phase II in IV semester

LIST OF ELECTIVES

First year (Semester I)

S. No.	Course Code	Course Name	L	T	P	C
1	PHEY 101	Crystal Growth Techniques	2	0	2	3
2	PHEY 102	Materials Processing	3	0	0	3
3	PHEY 103	Materials Characterization	2	0	2	3
4	PHEY 104	Functional Materials and Structures	3	0	0	3
5	PH]EY 105	Advanced Optics and Laser Technology	3	0	0	3
6	PHEY 106	Nonlinear Optics	3	0	0	3
7	PHEY 107	Optical Fiber Communication	2	0	2	3
8	PHEY 108	Nanoscience and Technology	3	0	0	3
9	PHEY 109	Laser Spectroscopy and its Applications	3	0	0	3

First year (Semester II)

S. No.	Course Code	Course Name	L	T	P	C
1	PHEY 201	Electro-Optic Materials and Devices	3	0	0	3
2	PHEY 202	Ferroelectric Materials and Devices	2	0	2	3
3	PHEY 203	Structure and Properties of Alloys	3	0	0	3
4	PHEY 204	Photonic Materials and Devices	3	0	0	3
5	PHEY 205	Numerical Methods and Programming	3	0	0	3
6	PHEY 206	Ultrasonics and Non-Destructive Testing	3	0	0	3
7	PHEY 207	Optoelectronic Devices	2	0	2	3
8	PHEY 208	Biophotonics	3	0	0	3
9	PHEY 209	Chaos, Solitons and Fractals	3	0	0	3

Second year (Semester III)

S. No.	Course Code	Course Name	L	T	P	C
1	PHEY 301	Mathematical Methods for Nonlinear Science	3	0	0	3
2	PHEY 302	Measurements and Instrumentation	3	0	0	3
3	PHEY 303	Biomedical Instrumentation	3	0	0	3
4	PHEY 304	Radiation Physics	3	0	0	3
5	PHEY 305	Density Functional Theory	3	0	0	3
6	PHEY 306	Nanophotonics	3	0	0	3
7	PHEY 307	Optical Computing	3	0	0	3
8	PHEY 308	Thin Film Science and Technology	3	0	0	3
9	PHEY 309	Corrosion Science and Technology	3	0	0	3
10	PHEY 310	Biomaterials	3	0	0	3
11	PHEY 311	Advanced Materials for Energy Applications	3	0	0	3

LIST OF OPEN ELECTIVE COURSES OFFERED TO M.S.C. PROGRAMMES UNDER REGULATIONS 2022

Sl. No.	Course Code	Course Title	L	T	P	C	Offering Department / School
1.	OEEY 731	Advanced Materials for Energy Applications	3	0	0	3	Physics
2.	OEEY 732	Alternative Energy Resources	3	0	0	3	Chemistry
3.	OEEY 701	Analytical Techniques	3	0	0	3	Chemistry
4.	OEEY 733	Biomass for Energy Applications	3	0	0	3	Chemistry
5.	OEEY 703	Biomaterials	3	0	0	3	Physics
6.	OEEY 704	Biomedical Instrumentation	3	0	0	3	Physics
7.	OEEY 705	Biophotonics	3	0	0	3	Physics

8.	OEEY 734	Corrosion and Corrosion Control	3	0	0	3	Chemistry
9.	OEEY 735	Corrosion Science and Technology	3	0	0	3	Physics
10.	OEEY 736	Environmental Chemistry	3	0	0	3	Chemistry
11.	OEEY 737	Fuel Cells for Sustainable Energy Production	3	0	0	3	Chemistry
12.	OEEY 738	Green and Sustainable Chemistry	3	0	0	3	Chemistry
13.	OEEY 739	Industrial Pollution Control	3	0	0	3	Chemistry
14.	OEEY 740	Introduction to Embedded System	3	0	0	3	ECE
15.	OEEY 741	Matlab Programming	3	0	0	3	ECE
16.	OEEY 710	Nanotechnology and Catalysis	3	0	0	3	Chemistry
17.	OEEY 715	Structural Interpretation of Materials	3	0	0	3	Chemistry
18.	OEEY 742	Surface Coating Technology	3	0	0	3	Chemistry
19.	OEEY 743	Thin Film Science and Technology	3	0	0	3	Physics

SEMESTER I

PHE 6101	CLASSICAL MECHANICS	L	T	P	C
SDG: 4		4	0	0	4

COURSE OBJECTIVES:

COB1: *To* provide the foundations of the advanced level mechanics

COB2: To learn Lagrangian and Hamiltonian mechanics

COB3: To understand Rigid body dynamics and small oscillations

COB4: To understand central force and nonlinear systems

COB5: To give an introduction to Relativistic Mechanics

MODULE I LAGRANGIAN FORMULATION 12

Mechanics of a system of particles. Constraints - Generalized coordinates, D'Alembert's principle and Lagrange's equations of motion - Velocity dependent potentials and dissipation function - Applications of Lagrangian formulation. Hamilton's (variational) principle and derivation of Lagrange's equations - shortest distance and Brachistrochrone - Generalized momenta and energy - conservation laws and cyclic coordinates. Simple applications of the Lagrangian formulation: L-C circuit – Linear harmonic oscillator and Atwood's machine.

MODULE II CENTRAL FORCE MOTION AND RIGID BODY DYNAMICS 12

Newton's Laws. Dynamical systems - Phase-space dynamics - stability analysis. Central force motion: The Kepler problem - Two body Collisions - Scattering in laboratory and Centre of mass frames. Rigid body dynamics: moment of inertia tensor - non-inertial frames and pseudoforces - Euler angles - Euler's equations of motion - Heavy symmetric top.

MODULE III HAMILTONIAN FORMULATION 12

Legendre transformation - Hamiltonian and Hamilton's equation of motion - Hamilton's equations from variational principle - Liouville's theorem - Canonical transformation and Poisson brackets. Hamilton-Jacobi equation for Hamilton's principle function - Hamilton's characteristic function - Application (Harmonic oscillator) - Separation of

variables - Action angle variables.

MODULE IV SMALL OSCILLATIONS AND INTRODUCTION TO NONLINEAR DYNAMICS **12**

Theory of small oscillations – Frequencies of free vibration and normal coordinates – Two coupled harmonic oscillators – Vibrations of a linear triatomic molecule. Classical Field Theory - Lagrangian and Hamiltonian formalisms for continuous system. Nonlinear dynamical systems: Mathematical implications of nonlinearity – Linear vs Nonlinear oscillators – Linear stability analysis - Classification of equilibrium points – Logistic map –– Period doubling phenomenon – definition of chaos – initial conditions – Linear and Nonlinear dispersive waves – solitons

MODULE V RELATIVISTIC MECHANICS **12**

Special theory of relativity - Lorentz transformations, relativistic kinematics and mass–energy equivalence. Addition of velocities - Galilean and Lorentz transformations - Invariance of Maxwell's equations under Lorentz transformation.

L – 60; TOTAL HOURS – 60

REFERENCES:

1. Golstein. H, Poole. C and Sofko. J, Classical Mecanics , Pearson Education, New Delhi, 2014.
2. B. D. Gupta and Satya Prakash, Classical Mechanics, Keder Nath Ram Nath Publishers, Meerut, 2020.
3. Upadhyaya. J.C., Classical Mechanics, Himalaya Publishing House, 2019.
4. Marion and Thorntron, Classical Dynamics of Particles and Systems, Fifth Edition, Holt Rinehart & Winston, 2012.
5. Panat. P.V, Classical Mechanics, Narosa Publishing Home, New Delhi, 2008.
6. Rana. N.C and Joag.P.S, Classical Mechanics, Tata Mc-Graw Hill Publishing Company Limited, New Delhi, 2017.
7. M.Lakshmanan and S.Rajasekar, Nonlinear dynamics: Integrability, Chaos and Spatio-temporal patterns, Springer-Verlag, 2003.
8. Steven H.Strogatz, Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering (Studies in Nonlinearity) 2nd Edition, 2015.

COURSE OUTCOMES:

CO1: understand the advanced level mechanics.

CO2: comprehend the basics of Lagranges equation and Hamiltonian equation for a system of particles

CO3: compare and discuss the principles of central force problem

CO4: get insights into dynamics of Rigid body and small oscillations

CO5: Understand the principles of relativistic mechanics and Nonlinear systems

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 4 : Ensuring inclusive and equitable quality education for all persons and promote lifelong learning opportunities.

Statement : The modules and topics mentioned in this course are designed to ensure all inclusive and thorough education with equity to all persons and promote learning opportunities at all times.

PHE 6102	MATHEMATICAL PHYSICS	L	T	P	C
SDG: 4		3	1	0	4

COURSE OBJECTIVES:

COB1: To provide a strong mathematical foundation in vector calculus, matrices

COB2: To discuss the properties of second order linear differential equations and special functions

COB3: To understand the complex variables

COB4: To learn about Fourier transform and Greens functions

COB5: To provide the basics of Tensor analysis and Group theory

MODULE I VECTORS AND MATRICES 12

Vector analysis: Gradient – Divergence – Curl – vector spaces – linear dependence and independence of vectors - second order derivatives Gauss's theorem - Stoke's theorem - Green's theorem – Curvilinear coordinates-spherical polar-cylindrical coordinates. Matrices: Orthogonal and Unitary Matrices, Matrix diagonalization, Cayley-Hamilton theorem - eigen values and eigen vectors.

MODULE II SECOND ORDER LINEAR DIFFERENTIAL EQUATIONS AND SPECIAL FUNCTIONS 12

Hermite, Legendre, Bessel and Laguerre differential equations –series solutions- generating functions-recurrence relations- Sturm Liouville theorem - Orthogonality of eigen function. Hyper geometric functions — generating functions.

MODULE III COMPLEX VARIABLES 12

Functions of complex variables – single and many valued functions-analytic functions – Cauchy – Riemann equations –conjugate functions – complex line integrals-Cauchy's integral theorem-integral formula – Taylor and Laurent expansions –zeros and singularities – residues –Cauchy's Residue theorem and its applications for evaluation of integrals.

MODULE IV FOURIER TRANSFORM AND GREEN FUNCTIONS 12

Fourier Transform: Fourier transform – sine and cosine transform – properties

Faultung'stheorem- application in heat conduction and spectroscopy. Laplace transforms – Inversetransforms – Linearity and Shifting theorems. Linear spaces – Basis-change of basis – Inner product space – Schmidt's orthogonalisation procedure – Schwartz's inequality – Hilbert spaces - properties. Green's function: Definition and construction – symmetry properties - expression for Green's functions in terms of Eigen functions - Green's functions for simple and second order operator.

MODULE V TENSORS AND GROUP THEORY 12

Tensor analysis : Cartesian tensors — law of transformation of first and second order tensors- addition, subtraction and multiplication (inner and outer product) of tensors –rank ,covariant, contravariant and mixed tensors-symmetric and antisymmetric tensors-Quotient law. Group Theory: Basic definitions-subgroups- permutation groups-Cyclic groups - cosets - Normal Subgroups-Isomorphism - Homomorphsim-Rotation groups - Reducible – Irreducible representations – Applications.

L – 45; T– 15; TOTAL HOURS –60

TEXT BOOKS:

1. G.B. Arfken, H.J.Weber and F.E. Harris, Mathematical Methods for Physicists,Seventh Edition, Academic Press, 2012
2. S.Andrilli and D.Hecker, Elementary Linear Algebra,Academic Press, 2006

REFERENCES:

1. G.B. Arfken, H.J.Weber and F.E. Harris, Mathematical Methods for Physicists,Seventh Edition, Academic Press, 2012
2. S.Andrilli and D.Hecker, Elementary Linear Algebra,Academic Press, 2006
3. Chattopadhyay. P.K, Mathematical Physics, 3rd Edition, New Academic Science,2014.
4. Joshi. A. W, Matrices and Tensors in Physics, 3rd edition, Wiley Eastern Ltd., NewDelhi, 1995.
5. Gupta. B. D., Mathematical Physics, 4th edition, Vikas Publishing House PvtLimited, 2007.
6. Murray Spiegel, Schaum's Outline of Advanced Mathematics for Engineers andScientists, Schaum's Outline Series, McGraw-Hill, 2009.

COURSE OUTCOMES:

CO1: understand the vector, vector fields, matrices and their need in science

CO2: apply knowledge in solving the second order linear differential equations and specialfunctions

CO3: solve the problems in complex variables

CO4: analyse knowledge in Fourier Transforms and green's functions

CO5: develop the essential mathematical skills to solve problems in tensors and grouptheory.

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHE 6103	ELECTROMAGNETIC THEORY AND ELECTRODYNAMICS	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To know the principles of electrostatics and magnetostatics.

COB2: To enable the student to explore the field of electrodynamics

COB3: To understand the basic concepts in electromagnetic wave and radiation

COB4: To study the laws governing the propagation of electromagnetic waves.

COB5: To enable the student to explore the field of electrodynamics

MODULE I ELECTROSTATICS 9

Coulomb's law, Gauss's law and applications, Electrostatic potential – Laplace andPoisson's equation — Laplace equation in three dimensions - Boundary value problems and uniqueness theorem, Polarization and displacement vectors - Boundary conditions - Dielectric sphere in a uniform field — Molecular polarisabilityand electrical susceptibility — Electrostatic energy in the presence of dielectric — Multipole expansion.

MODULE II MAGNETOSTATICS 9

Biot-Savart Law and its Applications, Ampere's circuital Law — Applications — Magnetic vector and scalar potential - Magnetic moment, force and torque on a current distribution in an external field - Magnetostatic energy - Magnetic induction and magnetic field in macroscopic media - Boundary conditions, Poisson's equation, inductance, energy density & applications.

MODULE III MAXWELL'S EQUATION 9

Faraday's laws of Induction - Maxwell's displacement current - Maxwell's equations —free space and linear isotropic media — Boundary conditions on the fields at interfaces -Vector and scalar potentials - Gauge invariance - Wave equation in one dimension - Coulomb and Lorentz gauges - Energy and momentum of the field - Poynting's theorem - Lorentz force - Conservation laws for a system of charges and electromagnetic fields.

MODULE IV ELECTROMAGNETIC WAVES & INTERACTION WITH MATTER 9

Electromagnetic waves in free space — Plane waves in non-conducting media - Linear and circular polarization, reflection and refraction at a plane interface-

Fresnel's law, interference, coherence and diffraction — Dynamics of charged particles in static and uniform electromagnetic fields - Waves in a conducting medium - Propagation in linear media — Reflection and transmission at Normal incidence — Reflection and Transmission at Oblique incidence –Laws of incidence and reflectance, Snell's law, Brewster law – Fresnel's equations.

MODULE V RELATIVISTIC AND QUANTUM ELECTRODYNAMICS 9

Four vectors - Lorentz transformation — invariance of Maxwell's equations under Lorentz transformation - invariance of D'Alembertian operator — invariance of Maxwell's field equations in terms of four vector — Radiation from moving charges and dipoles and retarded potentials - Quantum Electrodynamics (QED) — Introduction - S-Matrix and its expansion. Ordering theorems, Feynman graph and Feynman rules - Application - Rutherford scattering and Compton scattering.

L – 45; TOTAL HOURS –45

REFERENCES:

1. David J.Griffith, Introduction to Electrodynamics, 4th Edition, Pearson NewInternational Edition, New Delhi, 2014.
2. John David Jackson, Classical electrodynamics, 3rd edition, Wiley EasternLtd. (1999).
3. Zangwill A, Modern Electrodynamics, 1st edition, Cambridge (2013).
4. Reitz, John R.; Milford, Frederick J., Christy., Robert W., Foundations ofElectromagnetic Theory 4th ed. Addison Wesley (2008).
5. Gupta, Kumar, Singh, Electrodynamics, Pragati Prakashan (2001).
6. Capri A.Z. and Panat P.V., Introduction to Electrodynamics, NarosaPublishing House, 2010.
7. Satya Prakash, Electromagnetic theory and Electrodynamics, 10th edition,Kedar Nath and co., Meerut, 1999.
8. Matthew N.O, Sadiku, Elements of Electromagnetics, 3rd Ed. 2006

COURSE OUTCOMES:

CO1: Familiarize with the concepts of electrostatics and magnetostatics.

CO2: Apply Maxwell's equations to circuit theory.

CO3: Acquaint with the boundary conditions.

CO4: Gain knowledge on the propagation of electromagnetic waves.

CO5: Disseminate the principles of Quantum Electrodynamics.

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHE 6104	ANALOG, DIGITAL ELECTRONICS AND INSTRUMENTATION	L	T	P	C
SDG: 4		4	0	0	4

COURSE OBJECTIVES:

COB1: To understand the working functions and applications of semiconductor devices

COB2: To understand the basic operations and applications of op-amp

COB3: To perform the combinational logic circuit design

COB4: To understand the working aspects of optoelectronic devices

COB5: To gain basic knowledge about the instrumentation

MODULE I SEMICONDUCTOR DEVICES AND APPLICATIONS 12

Semiconductor junctions: Metal interconnects – metal semiconductor junction – Schottky barrier – Ohmic contacts – insulator-semiconductor junctions – semiconductor heterojunctions. Field effect transistors: Characteristics of FET and MOSFET, operation, FET amplifiers, FET switches, MOSFET logic switches, CMOS inverter, MOSFET current mirror, power MOSFET.

MODULE II ANALOG ELECTRONICS 12

Operational Amplifiers: Introduction - differential amplifiers – Op-Amp Parameters – negative feedback - comparators - mathematical operations– active filters. Oscillators: Feedback oscillator principles – oscillators with RC and LC feedback circuits – relaxation oscillators – 555 timer as an oscillator and Schmitt trigger. Log and antilog amplifier - Phase-locked Loop (PLL). Analog simulation circuits: Solving simultaneous equations, solving 2nd order linear (harmonic oscillator).

MODULE III DIGITAL ELECTRONICS 12

Analog versus digital – overview of logic functions and logic gates – CMOS digital gate circuits - combinational logic – flip-flops and related circuits – sequential logic – registers, counters, shift-registers and memory – microprocessor architecture (8085,8086,8088) – microcontroller (8051) – A/D and D/A conversion – DSP fundamentals.

MODULE IV OPTOELECTRONICS 12

Semiconductor heterojunctions – homojunction LED – Heterostructure LED – LED materials and structures – LED characteristics – phosphors and white

LEDs – LED electronics – semiconductor laser diode – laser diode characteristics. *pn* junction phototidode – *pin* photodiode – avalanche photodiode – heterojunction photodiode – phototransistors – solar cell - image sensors (CMOS and CCD).

MODULE V INSTRUMENTATION 12

Basics of instrumentation system – bridge circuits: Wheatstone, AC, Wien, capacitance and inductance comparison. Transducers: resistive, strain gauge, resistive thermometer, thermistor, LVDT, load cell, piezoelectric transducers. Signal conditioning – instrumentation amplifier- analog switches - sample & hold circuits - data acquisition and conversion- Voltage-to-frequency and frequency – to – voltage converters - data transmission – digital signal processing.

L – 60; TOTAL HOURS –60

REFERENCES:

1. Horowitz and Hill, The Art of Electronics, 3rd Edition, (Cambridge University Press, 2015).
2. Thomas F.Schubert,Jr. and Ernest M. Kim, Fundamentals of Electronics: Book 1,2,3,4 (Morgan & Claypool Publishers, 2016).
3. M.Morris Mano and Michael Ciletti, Digital Design (Pearson, Harlow, 2019).
4. Albert Paul Malvino, David J. Bates, Patrick E. Hoppe, Electronic Principles (McGraw-Hill, New Delhi, 2020)
5. Robert L.Boylestad and Louis Nashelsky, Electronic Devices and Circuit Theory (Pearson Education, New Delhi, 2013)
6. Anil K.Maini, Lasers and Optoelectronics (Wiley, England, 2013).
7. mesh K.Mishra and Jasprit Singh, Semiconductor Device Physics and Design (Springer, Netherlands, 2008).
8. Thomas L.Floyd and David M.Buchla, Analog Fundamentals: A systems approach (Pearson, Boston, 2013).
9. H.S.Kalsi, Electronic Instrumentation (McGraw-Hill, New Delhi, 2010).
10. Anil K.Maini, Digital Electronics: Principles, Devices and Applications (John Wiley & Sons Ltd., 2007).
11. S.O.Kasap, Optoelectronics and Photonics: Principles and Practices (Pearson, Boston,2013).
12. M. Lakshmanan, K. Murali, Chaos in Nonlinear Oscillators: Controlling and Synchronization, (World Scientific, 1996).

RESOURCES FROM WEB:

1. https://www.e1ectronicshub.org/ana1og-circuits-and-digital-circuits/#:
:text=Ana1og%20Circuits%20and%20Digital%20Circuits%20is%20a%20classic
%20way%20of,dea1s%20with%20discrete%20digital%20signals.
2. https://www.a11aboutcircuits.com/video-tutorials/analog-and-digital-electronics/
https://www.ece.utoronto.cmprospective-students/curriculum-streams/digital-analog/(* subject to availability - not to be used for exam purpose)
4. https://nptel.ac.in/courses/108101091 (Basic Electronics, Prof. B.Patil, IIT Bombay).
5. https://nptel.ac.in/courses/115102026 (Semiconductor Optoelectronics, Prof.M.R.Shenoy, IIT Delhi).

COURSE OUTCOMES:

CO1: understand the basic electronics circuit component

CO2: comprehend the basics of analog electronic circuit design understand the digital electronic circuit design

CO3: compare and correlate various types of digital electronic circuit design

CO4: get insights into optoelectronic devices

CO5: Understand the principles of electronic instrumentation systems.

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 4 : Ensuring inclusive and equitable quality education for all persons and promote lifelong learning opportunities.

Statement : The modules and topics mentioned in this course are designed to ensure all inclusive and thorough education with equity to all persons and promote learning opportunities at all times.

PHE 6105	ADVANCED ELECTRONICS LABORATORY	L	T	P	C
SDG: 4		0	0	4	2

COURSE OBJECTIVES:

This laboratory course is intended to give a practical knowledge of basic and essential electronics. This laboratory course helps students study the working principles of the elementary electronic components and design of various linear and nonlinear electronic circuits including analog simulation, filter circuits, optoelectronic and electronic instrumentation. The student will also be introduced to the digital circuits, microprocessors and microcontrollers.

Any fifteen experiments

1. Characteristics curve of FET (BFW10).
2. MOSFET Drain current and Transfer Characteristics (2N7000)
3. Measurement of op-amp parameters.
4. Basic operational amplifier circuits: Comparator, inverting amplifier, non-inverting amplifier, adder, difference amplifier, integrator, differentiator, summing-integrator.
5. Construction of simultaneous equation solving circuit using op-amps.
6. Construction of op-amp active filters - LPF, HPF, BPF.
7. Design of phase shift and Wien's Bridge oscillators.
8. 555 timer based astable multi-vibrator and Schmitt trigger circuits.
9. Construction of relaxation oscillators using Op-Amp.
10. Construction of op-amp instrumentation amplifier.
11. DAC using R-2R network.
12. ADC using IC-0800 or IC-0804
13. Construction of three terminal voltage regulator based circuits (LM 7805, LM7809).
14. Verification of truth tables of OR,AND,NOR,NAND logic gates.
15. Construction of XOR logic using universal logic gates.
16. Design and implementation of half/full-adder circuits.
17. 8085/8086 microprocessor based experiments.
18. Plotting the V-I characteristics of LED.
19. Studying the light-current characteristics of diode based photodetectors.
20. Plotting the V-I Characteristics of the solar cell and hence determine the fill factor.

P – 60; TOTAL HOURS – 60

COURSE OUTCOMES:

CO1: Draw the characteristic curve of FET, Op-amp, negative impedance converter.

CO2: Design op-amp circuits to carry-out mathematical operations.

CO3: understand Bias photodiodes and LEDs and extract basic figures of merit.

CO4: Design complex digital electronic circuits with universal logic gates.

CO5: Independently operate key electronic measurement equipment.

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 4 : Ensuring inclusive and equitable quality education for all persons and promote lifelong learning opportunities.

Statement : The modules and topics mentioned in this course are designed to ensure all inclusive and thorough education with equity to all persons and promote learning opportunities at all times.

ENE 6182	PROFESSIONAL COMMUNICATION	L	T	P	C
SDG: 4		2	1	0	3

COURSE OBJECTIVES:

COB1: To enhance the Employability and Career Skills of students

COB2: To orient the students towards grooming as a professional

COB3: To make them Employability Graduates

COB4: To train students making effective presentations and discussions on various topics.

COB5: To enable students learn the importance of workplace etiquette

MODULE I COMMUNICATION AT WORKPLACE 7

Language and communication-Communication at the workplace- Formal and informal communication- Direction of flow of communication- Non-verbal communication-Communication and organizational culture-Communication and inter- personal relations- Importance of the 'U' in communication.

MODULE II PRESENTATION SKILLS 11

Importance of presentation skills-Overcoming the fear of public speaking towards making effective presentations- A step-by-step approach to presentations –planning the presentation-Gathering feedback- Making the presentation.

MODULE III CORRESPONDENCE AT WORK 9

Importance of workplace correspondence-Types of correspondence-Mechanics of effective business correspondence-Tips for effective correspondence-The seven Cs of communication- Writing effective emails- Email etiquette-Personal touch in business communication.

MODULE IV TEAM WORK 11

Importance of team work-Understanding team behavior-Team as an employability skill-Team formation and development-Pooling competencies in a team- Significance of team spirit-How to be an effective team player – Group Discussion.

MODULE V WORKPLACE ETIQUETTE 7

Etiquette in modern workplace- Workplace etiquette- global and local Culture sensitivity-Gender sensitivity- importance of grooming-Etiquette in interaction-Netiquette.

L – 30; T-15; TOTAL HOURS – 45

REFERENCES:

1. Butterfield, Jeff Soft Skills for Everyone. Cengage Learning: New Delhi, 2015
2. Interact English Lab Manual for Undergraduate Students,.Orient Balck Swan: Hyderabad, 2016.
3. E. Suresh Kumar et al. Communication for Professional Success. Orient Blackswan: Hyderabad, 2015
4. Raman, Meenakshi and Sangeeta Sharma. Professional Communication. Oxford University Press: Oxford, 2014
5. S. Hariharanetal. Soft Skills. MJP Publishers: Chennai, 2010.

COURSE OUTCOMES:

CO1: Identify the flows of communication

CO2: Make effective presentations

CO3: Write effective business correspondences.

CO4: Participate in group discussions and team work confidently.

CO5: Follow appropriate workplace etiquette

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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SEMESTER II

		L	T	P	C
GEE 6202	**== AND INTELLECTUAL PROPERTY**				
SDG: 4, 9, 11 & 15	**RIGHTS**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

Students will be trained to

COB1: Basic concepts of Research.

COB2: Select and Define a research problem

COB3: Analyze and Interpret the Results

COB4: write Scientific and Technical reports & thesis

COB5: Apply the Copyrights, Patents and Intellectual Property Rights.

MODULE I INTRODUCTION TO RESEARCH METHODOLOGY **9**

Research: Objectives, Motivation and types - Approaches, Significance of Research, Research process, Criteria of good research, Problems encountered by researchers - Introduction to ethics, scientific conduct and misconduct, misconduct and why it occurs, fabrication, authorship issues, The investigation and punishment of scientific misconduct (Erratum).

MODULE II RESEARCH FORMULATION AND DESIGN **9**

Defining and formulating the research problem, selecting the problem, necessity of defining the problem, importance of literature review in defining a problem, literature review-primary and secondary sources, reviews, monograph, patents, research databases, web as a source, identifying gap areas from literature and research database, development of working hypothesis. Definition and importance of Journal Impact factor, Cite Scores and Citation Indexes.

MODULE III DATA COLLECTION, ANALYSIS AND INTERPRETATION OF DATA **9**

Observation and Collection of data, methods of data collection, sampling methods, data processing, analysis strategies and tools, data analysis with statistical tools (Sigma STAT, SPSS student, ANOVA), hypothesis testing. Importance and scientific methodology in recording results, importance of negative results, conceptions of error of measurement - absolute and relative errors, true score theory and generalisability theory. Measures of central tendency – mean median and mode.

MODULE IV SCIENTIFIC AND TECHNICAL WRITING 9

Different types of scientific and technical publications in the area of research - Technical writing skills for report, synopsis and thesis – organisation of contents and layout of the research reports, oral presentation, mechanics of writing a research report, precautions for writing research reports, conclusions. Preparing papers for international journals - software for paper formatting like LaTeX/MS Office, Grammarly - reference management software – Mendeley and detection of similarity index / plagiarism by Turnitin.

MODULE V INTELLECTUAL PROPERTY RIGHTS 9

The concept, Intellectual Property system in India, development of TRIPS complied regime in India, Patents Act, 1970, Trade Mark Act, 1999,The Designs Act, 2000, Commercialization, Copy Right, Royalty, Trade related aspects of Intellectual Property Rights (TRIPS); Geographical indications, Industrial designs, Enforcement of Intellectual Property Rights, Function of UNSECO in IPR maintenance. Patents, Patentable subject matter, Rights conferred, Exceptions, Term of protection, Conditions on Patent applicants, Process patents.

L – 45; TOTAL HOURS – 45

TEXT BOOKS:

1. Cooper Donald R, Schindler Pamela S and Sharma JK., 2012. “Business Research Methods”, Tata McGraw Hill Education, 11e.
2. Kothari C.R., “Research Methodology, Methods and Techniques”, Wiley Eastern Ltd., NewDelhi, 1991.

REFERENCES:

1. Anthony, M., Graziano, A.M. and Raulin, M.L., 2009. Research Methods: A Process of Inquiry, Allyn and Bacon.
2. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
3. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
4. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes .
5. Essentials of Research Design and Methodology Geoffrey R. Marczyk, David DeMatteo, David Festinger, 2005. John Wiley & Sons Publishers,

Inc

6. Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry, 2nd Edition, Irwin H. Segel, 1976. John Wiley & Sons Publishers, Inc
7. R Arora. Encyclopaedia of Research Methodology in Biological Sciences.Anmol Publishing, 2004.
8. Coghill M. and Gardson L.R., The ACS Style Guide Effective Communication of Scientific Information, 3rd Edn., Oxford University Press, 2006.

COURSE OUTCOMES:

The students will be able to

CO1: recognize the basic concepts of research and its methodologies

CO2: select and define appropriate research problem and parameters

CO3: apply packages for data collection, analyze and interpretation of data into reports.

CO4: write scientific report as journal article, thesis and technical proposal for funding.

CO5: propose research findings as publications, copyrights, trademarks and IPR.

Board of Studies (BoS) : 12th BoS of Chemistry held on 22.07.2022

Academic Council: 19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1													M		
CO2			H					M						M	
CO3		H			M										
CO4													H		M
CO5										H			H		

SDG 4 : Quality Education

SDG 9 : Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

SDG 11 : Sustainable Cities and Communities

SDG 15 : Life on Land

Statement : The understanding of concepts of high quality research, innovative thinking, knowledge on sustainable development and service to the society and mankind through quality research.

PHE 6201	QUANTUM MECHANICS	L	T	P	C
SDG: 4		4	0	0	4

COURSE OBJECTIVES:

COB1: To understand the basic concepts of quantum mechanics.

COB2: To know certain exactly solvable systems.

COB3: To provide the time dependent and independent perturbation theories.

COB4: To understand the scattering theory and angular momentum operators.

COB5: To give the applications of relativistic quantum mechanics.

MODULE I FOUNDATIONS OF QUANTUM MECHANICS 12

Postulates of quantum mechanics - Schrödinger equation: Time-dependent Schrödinger equation and its solution - Physical meaning and conditions on admissible wave functions - Conservation of probability– Expectation value - Ehrenfest′s theorem - Basic postulates. Operator Formulation: Linear operator - Adjoint and self-adjoint operators - Commuting and noncommuting operators - Commutator - Simultaneous eigenfunctions - Heisenberg uncertainty relation.

MODULE II EXACTLY SOLVABLE SYSTEMS 12

One dimensional Linear harmonic oscillator: Eigenvalues and eigenfunctions by solving the one dimensional Schrodinger equation– Particle in a box – Rectangular potential barrier potential – Tunnel effect – Rigid rotator – Hydrogen atom.

MODULE III APPROXIMATION METHODS 12

Time independent perturbation theory: Equations in various orders of time independent perturbation theory for non- degenerate case: first and second order corrections– Stark effect – Zeeman effect- Application to ground state of Helium atom – Time dependent perturbation theory: harmonic perturbation (Fermi-Golden Rule) - Adiabatic, Sudden Approximation perturbation.

MODULE IV SCATTERING THEORY AND ANGULAR MOMENTUM 12

Scattering theory: Scattering amplitude and cross-section – Green’s function

approach -- Born approximation and its application to square-well and screened Coulomb potentials. Angular momentum: Components of orbital angular momentum – Properties of L and L^2 – Eigen pairs of L^2 and L_z – Eigen states and Eigen values of of J^2 and J_z – addition of angular momentum – Glebsch Gorden coefficients - spin angular momentum – Pauli's spin matrices.

MODULE V RELATIVISTIC QUANTUM MECHANICS **12**

Klein-Gordon equation for a free particle - Probability and current densities - Plane wave solutions - Dirac equation for a free particle - Dirac matrices and their properties - Probability and current densities - Plane wave solutions - Negative energy states - Zitterbewegung: jittery motion of a free particle - Spin of a Dirac particle.

L – 60; TOTAL HOURS –60

REFERENCES:

1. David J. Griffiths, Introduction to Quantum Mechanics, Pearson Publication, 2020.
2. L. Schiff, Quantum Mechanics, Tata McGraw Hill, New Delhi, 2014, 4th edition.
3. Satya Prakash, Quantum Mechanics, Sultan Chand Publishers, New Delhi, 2004.
4. S. Rajasekar, R. Velusamy, Quantum Mechanics I: The Fundamentals, CRC Press, 2014.
5. S L Gupta, V Kumar, H V Sharma, Quantum Mechanics, Jai Prakash Nath Publications, 2015
6. P M Mathews, K.Venkatesan ,Text Book of Quantum Mechanics, 2nd Ed, Tata McGraw-Hill Education, 2017
7. A.K. Ghatak and S. Lokanathan, Quantum Mechanics: Theory & Applications (Macmillan, Chennai, 2004) 5th edition.
8. R. Shankar, Principles of Quantum Mechanics (Springer, New Delhi, 2007).

COURSE OUTCOMES:

CO1: Comphrend the basics of quantum mechanics and to apply it in different branches of Physics.

CO2: Analyze certain exactly solvable systems

CO3: Enable the students to explore the different approximation methods used in quantum mechanics.

CO4: Familiarize with the concepts of scattering theory and angular momentum and its importance.

CO5: Understand the applications of relativistic quantum mechanics.

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO 2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHE 6202	SOLID STATE PHYSICS	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To introduce crystal structure, band theory and lattice vibrations

COB2: To have comprehensive idea on properties of materials

COB3: To provide a sound knowledge of macroscopic properties derived from microscopic considerations

COB4: To understand basics of magnetic and dielectric materials

COB5: To give an introduction to superconducting and optical materials

MODULE I CRYSTAL STRUCTURE AND BONDING 9

General Description of Crystal Structures – Bravais lattices- Wigner Seitz cell- Cubic Structures: NaCl, CsCl, Diamond, Zincblende - HCP structures – Miller Indices-crystal directions - zones in crystals- interplanar distance (derivation) - The Reciprocal Lattice and its construction-Quasi crystals -Force between atoms- cohesive energy (derivation)- bonding in solids - binding energy of ionic crystals(derivation)-Madelung constant – Born Haber cycle.

MODULE II TRANSPORT PROPERTIES AND BAND THEORY OF SOLIDS 9

Free electron theory (Sommerfeld theory) – Fermi level-Fermi distribution function -electronic specific heat- electrical and thermal conductivity of metals Wiedemann Franz law (derivation)- Schroedinger wave equation- electron motion in periodic potential – Bloch's theorem – Kronig Penney model (derivation) - band theory of solids - Brillouin zone - Effective mass of electron and concept of hole- Fermi surface in metals and its characteristics – experimental determination of Fermi surface by De Haas van Alphen effect

MODULE III PHONONS : CRYSTAL VIBRATIONS AND THERMAL PROPERTIES 9

Vibrations of crystals with monoatomic lattice- dispersion relation (derivation) - Vibrations of crystals with diatomiclattice - dispersion relation (derivation)– optical and acoustical modes – number of normal modes of vibrations - Phonon momentum- inelastic scattering of photons by phonons – specific heat of solids- Einstein theory-Debye's theory of lattice specific heat(derivation) - anharmonic effects.

MODULE IV MAGNETIC AND DIELECTRIC PROPERTIES 9

Types of magnetic materials –Diamagnetism – Langevin's theory(derivation)- Paramagnetism – Hund's rules – rare earth ions-iron group ions-crystal field splitting-Pauli paramagnetism- Ferromagnetism – domain theory - Curie-Weiss law (derivation)- antiferromagnetism - ferrites. Dielectric Polarization and polarizability- dielectric constant- types of polarization (qualitative) and dependence on frequency and temperature-local electric field in an atom-ClausiusMossottirelation(derivation) -Piezo, pyro and ferroelectric properties of crystals.

MODULE V SUPERCONDUCTIVITY AND OPTICAL PROPERTIES 9

Properties of superconductor – critical magnetic field – Meissner effect (derivation) – Type I and Type II super conductors – superfluididty – entropy, heat capacity and energy gap of superconductor-quantum tunneling - London equations (derivation) –coherence length - BCS theory –RVB theory – theory of AC and DC Josephson effect – flux quantization-SQUID. Traps – Excitons – coloration of crystals - types of colour centers - Luminescence: fluorescence and phosphorescence

L – 45; TOTAL HOURS –45

REFERENCES:

1. Kittel. C, Introduction to Solid State Physics, 8th edition, Wiley Eastern, New Delhi, 2004.
2. Pillai. S.O, Solid State Physics, New Age International, New Delhi, 2009.
3. Blakemore. J. S, Solid State Physics, 2nd edition, Cambridge University Press, Cambridge, 1985.
4. Philip Hofmann, Solid State Physics, 1st edition, Wiley-VCH Publishers, 2011.
5. Wahab. A, Solid State Physics: Structure and Properties of Materials , Alpha Science International Ltd; 2nd Revised edition,2005
6. Raghavan.V, Materials science and Engineering: a first course, PHI Learning 5th Ed, 2004
7. Kashab S.O, Principles of Electrical Engineering Materials and Devices, McGraw Hill Int National publishers, 2000

COURSE OUTCOMES:

CO1: basic concepts on properties of materials in solid state physics.

CO2: phenomenon of superconductivity and its properties.

CO3: different techniques used for synthesis and fabrication of nanomaterials.

CO4: properties of solids with relevant theoretical knowledge

CO5: knowledge for specialization in condensed matter physics

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO 2	PSO3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 4 : Ensuring inclusive and equitable quality education for all persons and promote lifelong learning opportunities.

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PHE 6203	ATOMIC PHYSICS AND MOLECULAR SPECTROSCOPY	L	T	P	C
SDG: 4		4	0	0	4

COURSE OBJECTIVES:

COB1: To provide basic knowledge of modern atomic and molecular physics

COB2: To understand different spectroscopic studies on matter on the basis ofquantum mechanics

COB3: To master the experimental and theoretical methods in atomic and molecularspectroscopy

COB4: To gain knowledge about NMR and ESR spectroscopy

COB5: To obtain understanding on NQR and Mossbauer spectroscopy

MODULE I ATOMIC AND MOLECULAR STRUCTURE **12**

Atomic models: Vector atom model – Pauli's exclusion principle – Heisenberg's uncertainty principle – Types of spectra - Equation of motion of matters waves – operators - momentum and energy operators - eigen functions and eigen values —Many electron atoms – coupling schemes – Spin orbit interaction -energy levels – Spin functions of two and three electrons - Central field approximation: Thomas Fermi statistical model — Paschen back effect – Covalent bond - Hybridization: sp,sp^2, sp^3 - molecular orbital theory – Heitler London theory of Hydrogen ion and Helium molecule.

MODULE II INFRARED AND MICROWAVE SPECTROSCOPY **12**

Characteristic features of pure rotation – vibration – rotation and vibration of a diatomic molecule – theory – evaluation of molecular constants – IR spectra of polyatomic molecules – experimental techniques of IR – Dipole moment studies – molecular structure determination. Microwave spectra of polyatomic molecules – experimental techniques of microwave spectroscopy – inversion spectrum ofammonia – Maser principles – Ammonia Maser– applications of Masers.

MODULE III RAMAN SPECTROSCOPY **12**

Semi classical treatment of emission and absorption of radiation – emission and absorption coefficients — spontaneous and induced emission of

radiation — polarisability – Rayleigh scattering – Raman effect – basic principles of Raman scattering – vibrational and rotational Raman spectra – Experimental techniques ofRaman Spectroscopy- – molecular structure studies – Laser as a Raman source.

MODULE IV NMR AND ESR SPECTROSCOPY 12

NMR spectroscopy Basic principles- classical and quantum mechanical techniques - Bloch equations- spin- spin and spin- lattice relaxation times- experimental technique single coil and double coil methods- pulse ESR spectroscopy- basic principles- ESR spectrometer- Nuclear interaction and hyperfine structure- Relaxation effects- 'g' factor- biological applications.

-

MODULE V NQR AND MOSSBAUER SPECTROSCOPY 12

NQR spectroscopy- basic principles- quadrupole Hamiltonian- Nuclear quadrupole energy levels- for axial and non axial symmetry- NQR spectrometer- chemical bonding- molecular structure and molecular symmetry studies. Mossbauer spectroscopy-principle experimental arrangement - chemical shift- quadrupole splitting-applications.

L – 60; TOTAL HOURS –60

REFERENCES:

1. Sune Svanberg, Atomic and Molecular spectroscopy, 3rd Edition, SpringerPublishers, 2012.
2. Jain V. K., Introduction to Atomic And Molecular Spectroscopy, Alpha ScienceIntl Publishers, 2007.
3. Colin N. Banwell and Elaine M. McCash, Fundamentals of Molecularspectroscopy, McGraw-Hill College, 1994.
4. G.Aruldhas, Molecular structure and Spectrocopy, 2nd Ed., PHI learningPvt.Ltd. 2014.
5. R.Gopalan, P.S.Subramanian and K.Rengarajan, Elements of AnalyticalChemistry,Sultan Chand & sons, 2011
6. Jeanne L. McHale, Molecular spectroscopy, Prentice Hall, 1994

COURSE OUTCOMES:

CO1: explain the basic ideas about the various energy levels in matter

CO2: understand the concepts of different spectroscopic studies

CO3: carry out theoretical and experimental studies on molecular spectroscopy

CO4: focus on structure and dynamics of atoms and molecules

CO5: gain knowledge in Mossbauer and NQR spectroscopy towards chemical shiftand quadrupole splitting applications

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHE 6204	MATERIALS SCIENCE LABORATORY- I	L	T	P	C
SDG: 4		0	0	4	2

COURSE OBJECTIVES:

COB1: To gain in-depth knowledge in the field of materials science

COB2: To apply the concepts learnt through laboratory in various applications to meet the needs of the society.

COB3: To make the student familiarize with the basics of experimental physics

COB4: To enable the student to explore the concepts involved in the materials related experiments

COB5: To allow the student to apply the fundamentals of instruments Involved inapplications of materials science in materials.

MATERIALS SCIENCE
EXPERIMENTS-I

1. Four Probe experiment
2. Band gap determination using PN diode.
3. Determination of susceptibility – Quincke's Method
4. Hall effect experiment
5. Hysteresis curve, coercivity, retentivity, saturation magnetization determination of Ferroelectric substance
6. Determination of dielectric constant

P – 60; TOTAL HOURS – 60

COURSE OUTCOMES:

CO1: comprehend the different experimental techniques in materials science

CO2: apply the concepts of Physics principles and interpret them to carry out experiments.

CO3: apply the knowledge gained about the experimental techniques in differentthermal applications.

CO4: comprehend the ideas and principles involved in materials science related experiments

CO5: analyse various experimental techniques involving experimental procedures.

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHE 6205	OPTICS AND THERMAL LABORATORY	L	T	P	C
SDG: 4		0	0	4	2

COURSE OBJECTIVES:

COB1: To gain in-depth knowledge in the field of optics

COB2: To apply the concepts learnt through laboratory in various applications tomeet the epithetical needs of the society.

COB3: To make the student familiarize with the basics of experimental physics

COB4: To enable the student to explore the concepts involved in the thermodynamicsand heat

COB5: To allow the student to apply the fundamentals of instruments Involved inthermal process.

OPTICS EXPERIMENTS

1. Determination of wavelength of light using Michelson interferometer
2. Refractive index of a given liquid using Hollow prism method
3. Air – wedge experiment
4. Numerical aperture and acceptance angle of an optical fibre.
5. Particle size determination of different materials
6. Spectrometer experiment — determination of wavelength of prominentline of mercury spectrum.
7. Determination of Brewster angle using fibre optics
8. Fraunhoffer diffraction experiment
9. Fresnel diffraction experiment
10. Beam divergence of He – Ne laser semiconductor diode laser
11. Single mode fibre characteristics
12. Nonlinear optical studies using Pulsed Nd: YAG Laser
13. Demonstrate the principle of Rayleigh Scattering

THERMAL EXPERIMENTS

1. Radiation from a black body: Stefan-Boltzmann Law
2. Thermal conductivity of good conductors by Forbe's method.
3. To determine the Coefficient of Thermal Conductivity of Copper bySearle's and Angstrom's method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor byLee disc method.
5. To study the variation of Thermo-Emf of a Thermocouple with

Difference ofTemperature of its Two Junctions.

6. Measurement of Planck's constant using black body radiation.
7. Determination of Stefan's constant.
8. Specific heat of liquid – Newtons law of cooling
9. EMF of a thermocouple – Mirror galvanometer – Direct deflection method.
10. Verification of Newton's Law of cooling.
11. Thermal conductivity of a good conductor by Searle's method.
12. Temperature characteristics of thermistor.
13. Specific heat of liquid – Joule's Calorimeter

COURSE OUTCOMES:

CO1: comprehend the different experimental techniques in Advanced optics anduse it to analytical problems.

CO2: apply the concepts of Physics principles and interpret them to carry out experiments using interference, diffraction, polarization phenomenon.

CO3: apply the knowledge gained about the experimental techniques in differentthermal applications.

CO4: comprehend the ideas and principles involved in thermal experiments

CO5: analyse various experimental techniques involving thermal procedures.

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 4 : Ensuring inclusive and equitable quality education for all persons and promote lifelong learning opportunities.

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SEMESTER III

PHE 7101	LASER AND NON LINEAR OPTICS	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To understand the principles of the laser and optical resonators.

COB2: To know about the properties and types of lasers

COB3: To make the students to get familiarize with various applications of lasers.

COB4: To inculcate the knowledge of nonlinear optics.

COB5: To introduce the different aspects of nonlinear spectroscopy.

MODULE I PRINCIPLES OF THE LASER 9

Spontaneous emission, absorption and stimulated emission – Einstein coefficients and light amplification - active medium – population inversion – laser action – pump mechanism – pulsed and continuous wave lasers – coherent-state laser light. Laser rate equations: the two-level system, the three-level system, the four-level system, variation of laser power around threshold, cavity modes. Optical resonators: Modes of a rectangular cavity and open planar resonator, spherical mirror resonators, the quality factor, line-width of laser, mode selection. Pulsed and continuous wave lasers, Q-switching, mode locking, modes of general spherical resonator.

MODULE II PROPERTIES AND TYPES OF LASERS 9

Laser beam characteristics – Coherence properties of laser, spatial and temporal coherence. Laser systems: Ruby laser – Nd:YAG laser, He-Ne laser, CO_2 laser, dye laser. Fiber laser: basic equations of Erbium-doped fiber, fiber lasers, fiber amplifier, mode locking. Semiconductor laser: Basics, optical gain in semiconductors, gain coefficient, quantum well laser, semiconductor laser materials, laser diode characteristics, VCSELs, optical parametric oscillators.

MODULE III APPLICATIONS OF LASERS 9

Spatial frequency filtering and holography, laser induced fusion, light-wave communication, Drilling, Cutting, and Welding – Nuclear fusing with lasers – Communication by lasers – lasers in isotope separation . Lasers in industry: laser welding, hole drilling, laser cutting, LIDAR, lasers in medicine, precision length

measurement, laser interferometry, velocity measurement.

MODULE IV BASICS OF NONLINEAR OPTICS 9

Wave propagation in an anisotropic crystal – Nonlinear polarization of an optical medium – second-order nonlinear frequency mixing – third-order nonlinear frequency mixing – induced refractive index changes – self-focusing, self phase modulation, and spectral self-broadening – stimulated scattering of intense coherent light – SBS – SKS – optical phase conjugation.

MODULE V NONLINEAR SPECTROSCOPY 9

Ultrahigh resolution laser spectroscopy – saturation spectroscopy – two-photon absorption spectroscopy – coherent Raman spectroscopy – laser polarization spectroscopy – laser cooling and trapping spectroscopy – optical bi-stability – optical temporal solitons – fiber soliton lasers – optical spatial solitons – multi-photon nonlinear optical effects – nonlinear photoelectric effects – fast and slow light – Terahertz nonlinear photonics.

L – 45; TOTAL HOURS – 45

REFERENCES:

1. 1.K.Thyagarajan and A.Ghatak, *Lasers: Fundamentals and Applications* (Springer, New York, 2010).
2. K.R. Nambiar, *Lasers: Principles, Types and Applications* (New Age International Publishers Ltd, New Delhi, 2014).
3. William T.Silfvast, *Laser Fudamentals* (Cambridge University Press, Cambridge, 2004).
4. Guang S.He, *Nonlinear Optics and Photonics* (Oxford University Press, Oxford, 2015)
5. Peter E.Powers and Joseph W.Haus, *Fundamentals of Nonlinear Optics* (CRC Press, Boca Raton, 2017).

COURSE OUTCOMES:

CO1: Explain the fundamentals of Laser

CO2: Brief out the various characteristics of lasers

CO3: Describe the applications of lasers in industry and medicine.

CO4: Know about basics of nonlinear optics

CO5: Understand the various aspects of nonlinear spectroscopy.

Board of Studies (BoS) :
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19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PS O2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHE 7102	THERMODYNAMICS AND	L	T	P	C
SDG: 4	STATISTICAL PHYSICS	4	0	0	4

COURSE OBJECTIVES:

COB1: To understand the concepts of thermodynamics

COB2: To provide the kinetic theory of gases

COB3: To acquire the knowledge of classical statistical mechanics

COB4: To learn about quantum statistical mechanics

COB5: To understand the applications of quantum statistical mechanics

MODULE I REVIEW OF THERMODYNAMICS 12

hermodynamic equilibrium – thermodynamic processes - first law of thermodynamics – entropy and second law of thermodynamics – Nernst heat theorem and third law of thermodynamics – specific heat capacity - Enthalpy - Thermodynamic potentials –– Maxwell's thermodynamic relations - Gibb's-Helmholtz relations -. Applications of Maxwell's thermodynamic relations.

MODULE II KINETIC THEORY 12

Boltzmann transport equation and its validity – Boltzmann's H-theorem– Relation between H-function and entropy – Maxwell-Boltzmann distribution – Mean free path – Conservation laws – Transport phenomena – Viscosity of gases – Thermal conductivity – Diffusion process.

MODULE III CLASSICAL STATISTICAL MECHANICS 12

Review of probability theory –micro and macro states – postulate of equal priori probability-Phase space –Density distribution in phase space – Liouville's theorem – – Equipartition theorem - Ideal gas: Maxwell –Boltzmann (MB) distribution , Entropy, Partition function – Statistical ensembles – microcanonical, canonical and grand canonical ensembles: Partition function of canonical and grand canonical ensembles.

MODULE IV QUANTUM STATISTICAL MECHANICS 12

Basic concepts – Gibb's paradox -Sackur-Tetrode equation – The quantum distribution functions : Maxwell –Boltzmann distribution - Ideal quantum gases: Bosons and Fermions – Bose-Einstein (BE) distribution : evaluation of partition function –Fermi-Dirac (FD)distribution: evaluation of partition function - The Boltzmann limit of Boson and Fermion gases - Bose-Einstein condensation –

Liquid helium- Comparison of classical and quantum statistics.

MODULE V APPLICATIONS OF QUANTUM STATISTICAL MECHANICS 12

Ideal Bose System: Photon gas: radiation pressure, entropy of thermal photons, and radiation density -Planck's law of Black body radiation using BE statistics – Phonon gas: Debye theory of Specific heat from lattice vibration using BE statistics -. Ideal Fermi System- Electron gas: Fermi gas in metals- Fermi energy –Fermi temperature– Degeneracy – Pauli paramagnetism - Ferromagnetism: Ising and Heisenberg models.

L – 60; TOTAL HOURS –60

REFERENCES:

1. Frederick Reif, Fundamentals of statistical and thermal physics, McGraw-Hill, 2008.
2. Agarwal B.K. and Eisner M, Statistical Mechanics, 2nd Edition, New Age International, New Delhi, 1998.
3. Sears F.W and Salinger G.L, Thermodynamics, kinetic theory and statistical thermodynamics, Narosa publishing House, 1998.
4. Huang. K, Statistical Mechanics, Wiley Eastern Ltd., 2nd Edition, New Delhi,1987.
5. Bhattacharjee J.K, Statistical Mechanics: An Introductory Text, Allied Publication, New Delhi, 1996.

COURSE OUTCOMES:

CO1: fundamentals of thermodynamical systems

CO2: Brief out the kinetic theory of gases

CO3: ensemble appproach to solve classical and quantum thermodynamic systems

CO4: way to obtain partition function and their applications in calculating thermodynamical quantitites

CO5: classical and quantum statistical mechanics

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHE 7103	NUCLEAR AND PARTICLE PHYSICS	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To acquire the knowledge of basic properties of nucleus.

COB2: To have an idea on the nature of nuclear forces.

COB3: To get an insights into nuclear reactions within nucleus.

COB4: To get familiarized with the concepts of radioactivity

COB5: To gain the knowledge of elementary particles.

MODULE I NUCLEAR STRUCTURE 9

Basic properties: nuclear size-nuclear radius-estimation of nuclear size - nuclear structure, Rutherford's formula for alpha particle scattering - magnetic moments - systematics of stable nuclei - semi empirical mass formula of Weizsacker - nuclear stability - mass parabolas- liquid drop model- shell model.

MODULE II NUCLEAR FORCES 9

Ground state of deuteron – Orbitals in deuteron – Non central forces of deuteron - magnetic dipole moment of deuteron-square well potential of deuteron- Neutron- neutron, proton-proton forces – Yukawa potential -Meson theory of nuclear forces- Scattering Processes: The scattering problem-formulation- scattering amplitude- Low energy neutron-proton scattering - phase shifts- scattering length and effective range.

MODULE III RADIOACTIVITY 9

Alpha particle emission- Geiger Nuttal law- Gamow’s theory of alpha decay- Rotational spectra-fine structure of alpha spectra-beta decay- Neutrino hypothesis- Fermi’s theory of beta decay-Fermi and G.T.Slection rules- pair production- annihilation - Gamma emission-selections rules- transition probability-internal conversion- nuclear isomerism.

MODULE IV NUCLEAR REACTIONS 9

Energies of Nuclear reaction- level widths - cross sections- compound nucleus model- resonance scattering-scattering matrix- reciprocity theorem- Breit-Wigner one level formula- optical model- direct reactions- Stripping and pick-up reactions- Fission and fusion reactions- elementary ideas of fission reaction- theory of fission- elementary ideas of fusion- controlled

thermonuclear reactions- ideas of nuclear reactors.

MODULE V ELEMENTARY PARTICLES 9

Classification of fundamental elementary particles- interaction between elementary particles-hadrons & leptons - isospin strangeness- Gell Mann Nishijima's formula- symmetry of elementary particles-weight diagrams- quark model- CPT theorem - elementary ideas of gauge theory of strong and weak interactions – Higg's boson particle.

L – 45; TOTAL HOURS – 45

REFERENCES:

1. Tayal D.C., Nuclear Physics, Himalaya Publishing House, 1997.
2. Khanna M.P., Introduction to Particle Physics, Prentice Hall of India, 2004.
3. Williams W. S. C., Nuclear and Particle Physics, Oxford University Press, 1991.
4. Brian Martin, Nuclear and Particle Physics: An Introduction, Wiley Publishers, 2011.
5. I. S. Hughes, Elementary Particles, Cambridge University Press.
6. Roy and Nigam, Nuclear Physics, Wiley.

COURSE OUTCOMES:

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

CO1: explore the basic concepts of nucleus and its properties

CO2: explore the basic ideas and comprehend concepts of Nuclear forces

CO3: get an exposure of radioactivity concepts

CO4: apply the concepts of quantum forces in nuclear reactions

CO5: gain knowledge on elementary particles.

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHE 7104	MATERIALS SCIENCE LABORATORY-II	L	T	P	C
SDG: 4		0	0	4	2

COURSE OBJECTIVES:

COB1: To gain in-depth knowledge in the field of materials science

COB2: To apply the concepts learnt through laboratory in various applications to meet the needs of the society.

COB3: To make the student familiarize with the basics of experimental physics

COB4: To enable the student to explore the concepts involved in the materials related experiments

COB5: To allow the student to apply the fundamentals of instruments Involved inapplications of materials science in materials.

MATERIALS SCIENCE EXPERIMENTS-II

1. Laser divergence, wavelength determination-Using Wavelength particle size determination.
2. Crystal growth technique- Solution method
3. Density Functional Theory – Band structure and Density of states
4. Non linear study of crystals using Laser.
5. Ultrasonics – Interferometer(research type)

P – 60; TOTAL HOURS – 60

COURSE OUTCOMES:

CO1: comprehend the different experimental techniques in materials science

CO2: apply the concepts of Physics principles and interpret them to carry out experiments.

CO3: apply the knowledge gained about the experimental techniques in differentthermal applications.

CO4: comprehend the ideas and principles involved in materials science related experiments

CO5: analyse various experimental techniques involving experimental procedures.

Board of Studies (BoS) : BOS of Physics was held on 30.6.22

Academic Council: 19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

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ELECTIVES
SEMESTER 1

PHEY 101	**CRYSTAL GROWTH TECHNIQUES**	**L**	**T**	**P**	**C**
SDG: 4		**2**	**0**	**2**	**3**

COURSE OBJECTIVES:

COB1: To get the basic understanding on Crystal-Symmetry operations and various defects in crystals

COB2: To understand and compare the various solution - based Crystal Growth techniques

COB3: To know the principle in the methods involved in the growth of crystal using melt growth process

COB4: To study the applications of single crystals in non-linear optics

MODULE I CRYSTALLOGRAPHY 7

Symmetry elements, operations - translational symmetries - point groups - space groups - equivalent positions –close packed structures - voids - important crystal structures – defects in crystals, – polymorphism and twinning - polarizing microscope and uses

MODULE II GROWTH FROM SOLUTIONS 8

Introduction to crystal growth – nucleation - Measurement of super saturation - solution growth methods – low and high temperature solution growth methods – vapour growth – Crystal growth in gel – Growth of biological crystals – Hydrothermal technique – Sol-gel growth – unidirectional growth of crystals from solution. Accelerated crucible rotation technique (ACRT)

MODULE III MELT GROWTH 7

Temperature measurement and control – Starting materials and purification - conservative and non-conservative process – Bridgman method – Czochralski method – Verneuil method – Zone melting – Zone refining- Skull melting

MODULE IV APPLICATIONS OF LINEAR AND NON-LINEAR CRYSTALS 8

Nonlinear Optics in Linear Photonic Crystals - Phase Matching - Nonlinear Photonic Crystal Analysis – Nonlinear photonic crystals – photonic crystal fibers – photonic crystal sensor - Materials: $LiNbO_3$, Chalcogenide Glasses, etc., Wavelength

Converters, etc.

L – 30; P –30; TOTAL HOURS – 60

LIST OF EXPERIMENTS:

1. Growth of crystal by slow evaporation technique
2. Growth of crystals from temperature reduction method.
3. Determination of melting point of given crystal.
4. Solubility test for different materials.
5. Determination of Meta-stable zone width.
6. Hydrothermal method of crystal growth
7. Sol-gel method of growing crystals
8. Characterization of second harmonic crystals
9. Simulation of crystal structures using DFT

REFERENCES:

1. Brice J.C., Crystal Growth Processes, John Wiley and Sons, New York, 1987.
2. Santhana Ragavan P. and Ramasamy P., Crystal Growth Processes and Methods, KRU Publications, Kumbakonam, 2001.
3. Scheel, Hans J. and Fukuda, Crystal Growth Technology, Wiley publishers, 2004.
4. Hans J. Scheel and Peter Capper, Crystal Growth Technology: From Fundamentals and Simulation to Large-scale Production, Wiley publishers, 2008.

COURSE OUTCOMES:

CO1: compare and analyze the various techniques of crystal growth

CO2: Apply the principles of crystal growth techniques in laboratory practices

CO3: Understand the nuances of melt-growth technique

CO4: Approach crystal growth techniques holistically and extend it to study of non- linear crystals

Board of Studies (BoS) :
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19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

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PHEY 102	MATERIALS PROCESSING	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To introduce the basic concepts of physics of materials processing

COB2: To provide knowledge of surface treatment processes

COB3: To study about different welding processes

COB4: To discuss various types of mechanical working of metals

COB5: To give the basics of powder metallurgical process

MODULE I BASIC MANUFACTURING PROCESSES 9

Fundamental analysis of Manufacturing processes, casting, casting processes, forging, methods of forging, extrusion, rolling, spinning, turning, planning and shaping, milling, grinding.

MODULE II SURFACE TREATMENT PROCESSES 9

Necessity for surface modification, surface cladding, surface alloying, hard facing, shock hardening, conventional methods, carburizing, nitriding, cyaniding, advantages of laser surface treatment over conventional methods, typical laser variables used in surface alloying, laser cladding, experimental set up.

MODULE III WELDING PROCESSES 9

Various processes of welding, fusion welding, pressure welding, oxyacetylene welding, resistance welding, spot welding, thermite welding, projection welding, seam welding, butt welding, thermal effects of welding, effects on grain size and microstructure, internal stresses effect, corrosion effect, high energy beam welding, laser beam and electron beam welding, key hole effect.

MODULE IV MECHANICAL WORKING OF METALS 9

Hot working, cold working, normalizing, full annealing, tempering, theory of tempering, effect of tempering temperature on mechanical properties of carbon steels, different tempering process, deformation of metals, elastic deformation, plastic deformation, slip, twinning.

MODULE V POWDER METALLURGICAL PROCESS 9

Production of powders, powder mixing, compacting, types of presses,

sintering,soaking, finishing process, limitations and advantages of powder metallurgy, applications, production of cemented carbide cutting tools, self-lubricating bearings, magnets, cermets, ultrasonic ceramic transducers.

L – 45;TOTAL HOURS: 45

REFERENCES:

1. Rajan T.V, Sharma C.P and Ashok Sharma Heat treatment - Principles and Techniques, Prentice Hall of India Pvt. Ltd. New Delhi, 1995.
2. Muralidhara, M.K., Materials Science and Processes, Dhanpat Rai Publishing Co., New Delhi, 1998.
3. Rykalin, Uglov A, Kokona, A Laser and Electron beam material processing hand book, MIR Publishers, 1987.
4. Gupta, R.B. Materials Science and Processes, Satya Prakashan, New Delhi, 1995.

COURSE OUTCOMES:

CO1: basic manufacturing process such as casting, rolling, turning, shaping

CO2: various surface treatment process such as hardening, nitriding etc

CO3: a various welding process in materials processing

CO4: Mechanical working processes such as hot working, cold working, twinning

CO5:powder metallurgical process such as mixing, compacting, sintering and applications

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

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PHEY 103	MATERIALS	L	T	P	C
SDG: 4	CHARACTERIZATION	2	0	2	3

COURSE OBJECTIVES:

COB1: To get knowledge on thermal analysis of materials using TGA, DTA and DSC

COB2: To study on microscopic analysis

COB3: To study on electrical analysis of various materials

COB4: To obtain knowledge on spectroscopic analysis

MODULE I THERMAL ANALYSIS 7

Introduction – thermogravimetric analysis (TGA) –instrumentation – determination of weight loss and decomposition products – differential thermal analysis (DTA)- cooling curves - differential scanning calorimetry (DSC) – instrumentation – specific heat capacity measurements.

MODULE II OPTICAL AND ELECTRON MICROSCOPIC METHODS 10

Optical Microscopy: optical microscopy techniques – Bright field optical microscopy – Dark field optical microscopy – phase contrast microscopy - fluorescence microscopy - scanning probe microscopy (STM, AFM) - SEM, EDAX, ESCA, EPMA, TEM: working principle and Instrumentation - Photoluminescence – light–matter interaction – instrumentation – Applications

MODULE III ELECTRICAL METHODS 7

Two probe and four probe methods- van der Pauw method – Hall probe and measurement – scattering mechanism – C-V characteristics – Schottky barrier capacitance – impurity concentration – electrochemical C-V profiling – limitations.

MODULE IV SPECTROSCOPY 6

Principles and instrumentation for UV-Vis-IR, FTIR spectroscopy, Raman spectroscopy, SIMS-proton induced X-ray Emission spectroscopy (PIXE).

L-30; P – 30; TOTAL HOURS- 60

LIST OF EXPERIMENTS:

1.Growth of crystals from temperature reduction method.

2.Determination of melting point of given crystal.

3.Solubility test for different materials.
4.Determination of Meta-stable zone width.
5.Hydrothermal method of crystal growth
6.Sol-gel method of growing crystals
7.Characterization of second harmonic crystals
8.Simulation of crystal structures using DFT

REFERENCES:

1. Stradling,R.A; Klipstain, P.C; Growth and Characterization of semiconductors, Adam Hilger, Bristol,1990.
2. Belk, J.A; Electron microscopy and microanalysis of crystalline materials, Applied Science Publishers, London, 1979.
3. Lawrence E.Murr, Electron and Ion microscopy and Microanalysis principles and Applications, Marcel Dekker Inc., New York, 1991
4. D.Kealey&P.J.Haines, Analytical Chemistry, Viva Books Private Limited, New Delhi 2002.
5. Hobart Hurd Willard, Lynne Lionel Merritt, Instrumental Methods of Analysis, 6th ed, CBS Publishers & Distributors, 1986.

COURSE OUTCOMES:

CO1: interpret data obtained through the characterization techniques

CO2: explain various thermal analysis

CO3: illustrate microscopic analysis using FESEM, TEM and STM

CO4: interpret the electrical analysis of various materials

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO 2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

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PHEY 104	FUNCTIONAL MATERIALS AND STRUCTURES	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To enable the students understand importance and structure of smart materials

COB2: To gain knowledge on application of function materials for sensor applications

COB3: To understand the electro rheological functional materials

COB4: To understand the theory behind piezoelectric materials

COB5: To make the students understand the applications of smart materials towards shape memory alloys

MODULE I INTRODUCTION AND HISTORICAL PERSPECTIVE **9**

Classes of materials and their usage – Intelligent /Smart materials – Evaluation of materials Science – Structural material – Functional materials – Poly functional materials – Generation of smart materials – Diverse areas of intelligent materials – Primitive functions of intelligent materials – Intelligent inherent in materials – Examples of intelligent materials, structural materials, Electrical materials, bio- compatible materials etc. – Intelligent biological materials – Biomimetics – Wolff's law – Technological applications of Intelligent materials.

MODULE II FUNCTIONAL MATERIALS AND STRUCTURAL SYSTEMS **9**

The principal ingredients of smart materials – Thermal materials – Sensing technologies – Micro sensors – Intelligent systems – Hybrid smart materials – An algorithm for synthesizing a smart material – Passive sensory smart structures– Reactive actuator based smart structures – Active sensing and reactive smart structures – Smart skins – Aero elastic tailoring of airfoils – Synthesis of future smart systems.

MODULE III ELECTRO-RHEOLOGICAL (FLUIDS) FUNCTIONAL MATERIALS **9**

Suspensions and electro-rheological fluids – Bingham-body model – Newtonian viscosity and non-Newtonian viscosity – Principal characteristics of electro rheological fluids – The electro-rheological phenomenon – Charge migration mechanism for the dispersed phase – Electro-rheological fluid domain – Electrorheological fluid actuators – Electro-rheological fluid design parameter – Applications of Electrorheological fluids.

MODULE IV PIEZOELECTRIC FUNCTIONAL MATERIALS **9**

Background – Electrostriction – Pyro electricity – Piezoelectricity – Industrial piezoelectric materials – PZT – PVDF – PVDF film – Properties of commercial Piezoelectric materials – Properties of piezoelectric film (explanation) – Smart materials featuring piezoelectric elements – Smart composite laminate with embedded piezoelectric actuators – SAW filters.

MODULE V SHAPE – MEMORY (ALLOYS) FUNCTIONAL MATERIALS **9**

Background on shape – Memory alloys (SMA) Nickel – Titanium alloy (Nitinol) – Materials characteristics of Nitinol – Martensitic transformations – Austenitic transformations – Thermoelastic martensitic transformations – Cu based SMA, chiral materials – Applications of SMA – Continuum applications of SMA fastners – SMA fibers – reaction vessels, nuclear reactors, chemical plants, etc. – Micro robot actuated by SMA – SMA memorization process (Satellite antenna applications) SMA blood clot filter – Impediments to applications of SMA – SMA plastics – Primary molding – secondary molding – Potential applications of SMA plastics

L - 45 ;TOTAL HOURS - 45

REFERENCES:

1. M.V.Gandhi and B.S. Thompson, Smart Materials and Structures Chapman and Hall, London, First Edition, 1992
2. T.W. Deurig, K.N.Melton, D.Stockel and C.M.Wayman, Engineering aspects of Shape Memory alloys, Butterworth –Heinemann, 1990
3. C.A.Rogers, Smart Materials, Structures and Mathematical issues, TechnomicPublising Co., USA, 1989.

COURSE OUTCOMES:

CO1: illustrate structure and properties of smart materials and their applications in Science & Technology

CO2: explore the various application of functional materials towards sensors technology

CO3: comprehend the concept behind electro rheological functional materials

CO4: get necessary exposure to theory and principles of piezoelectric materials

CO5: study the applications of smart materials towards shape memory alloys

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 4 : Ensuring inclusive and equitable quality education for all persons and promote lifelong learning opportunities.

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PHEY 105	ADVANCED OPTICS AND LASER TECHNOLOGY	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To know the role of advanced optics in laser technology

COB2: To understand the imaging techniques applications

COB3 To understand the various mechanisms involving operation of laser

COB4: To get knowledge on various switching modes of lasers

COB5: To get practical knowledge towards applications of lasers

MODULE I THEORY OF DIFFRACTION 9

Kirchoff's theorem – Fresnel – Kirchoff integral formula and its application to diffraction problems - Wave propagation in free space - Fraunhofer and Fresnel diffraction, Fraunhofer diffraction by a single slit, double slit, diffraction grating, circular aperture - Fresnel diffraction, Fresnel zones, Fresnel integrals.

MODULE II FOURIER OPTICS 9

Concept of spatial Frequencies, Impulse response and transfer functions-Fourier Transform properties of lens - spatial filtering - theory of imaging (Focused and non-focused) - Pupil functions - Abbe's principle.

MODULE III LASER SYSTEMS 9

Laser systems – General description-Laser structure-excitation mechanism-Different laser systems- He-Ne laser, Argon-ion laser, Nitrogen laser, Carbon-dioxide laser - Excimer laser - X-ray laser - Free electron laser, Nd:YAG; Nd:Glass, Alexandrite laser - Ti-Sapphire laser – Diode pumped solid state laser, Pulsed-CW dye laser.

MODULE IV Q-SWITCHING, MODE LOCKING AND COHERENCE OF LASER 9

Theory of Q-switching and experimental methods - cavity dumping -Theory of Mode locking and experimental methods - Spatial and Temporal coherence - Methods of detection and measurement of ultrashort pulses.

MODULE V LASER APPLICATIONS 9

Cooling and Trapping of Atoms, Principles of Doppler and Polarization Gradient Cooling, Qualitative Description of Ion Traps, Optical Traps and Magneto-Optical Traps, Evaporative Cooling and Bose Condensation. Medical applications - laser and

tissue interaction – laser instrument of surgery

L - 45 ;TOTAL HOURS - 45

REFERENCES:

1. Born and Wolf, Principles of Optics, Cambridge University press, 1999.
2. Saleh and Tiech, Fundamentals of photonics, Wiley-Interscience Publishers, 2007.
3. Guenther. R.D., Modern Optics, John Wiley Publishers, 1990.
4. William T. Silfvast, Laser Fundamentals, Cambridge University press, 1996.
5. Robert Boyd. W, Non Linear Optics, 3rd edition, Academic Press, 2008.

COURSE OUTCOMES:

CO1: illustrate the characteristics of the laser systems
CO2: explain the imaging techniques using lasers
CO3: elaborate the pumping mechanism of lasers
CO4: explore Q-switching process in lasers and method of detection
CO5: study various applications of laser systems.

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
19th AC held on 29.09.2022

	PO 1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHDY 106	NONLINEAR OPTICS	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To teach the principles of nonlinear optics and origin of optical nonlinearities.

COB2: To analyze various types of nonlinearities in optics and its applications.

COB3: To study about third order nonlinearities and Kerr effect

COB4: To provide the basics of photorefractive materials and multiphoton processes

COB5: To give the details of different kinds of scattering processes

MODULE I INTRODUCTION TO NONLINEAR OPTICS 9

Wave propagation in an anisotropic crystal – Polarization response of materials to light – Harmonic generation – Second harmonic generation – Sum and difference frequency generation – Phase matching – Third harmonic generation – bistability – self focusing.

MODULE II NONLINEAR PROCESSES 9

Propagation of Electromagnetic Waves in Nonlinear medium, Self Focusing, Phase matching condition, Fiber Lasers, Stimulated Raman Scattering and Raman Lasers, CARS, Saturation and Two photon Absorptions.

MODULE III THIRD ORDER NONLINEARITIES 9

Two photon process – Theory and experiment – Three photon process Parametric generation of light – Oscillator – Amplifier – Stimulated Raman scattering – Intensity dependent refractive index optical Kerr effect – photorefractive, electron optic effects.

MODULE IV MULTIPHOTON PROCESSES 9

Electro-optic effects – Electro-optic modulators - Photorefractive effect - Two beam coupling in Photorefractive materials – Four wave mixing in Photorefractive materials.

MODULE V STIMULATED SCATTERING PROCESSES 9

Stimulated scattering processes – Stimulated Brillouin scattering – Phase

conjugation – Spontaneous Raman effect – Stimulated Raman Scattering – Stokes – Anti-Stokes Coupling in SRS – Stimulated Rayleigh - Wing Scattering.

L - 45 ;TOTAL HOURS - 45

REFERENCES:

1. Robert W. Boyd, “Non-linear Optics”, Academic Press, London, 5th Edition, 2008.
2. A.Yariv, Opto Electronics, Third Edition, John Wiley and Sons, New York,1990.
3. P.N.Butcher and D.Cotter, “The Elements of Nonlinear Optics”, CambridgeUniv. Press, New York, 1990.
4. YVGS Murthi and C. Vijayan, Essentials of Nonlinear Optics, Ane/Athena Books 1st Edition (2014)

COURSE OUTCOMES:

CO1: explain the principles of nonlinear optics,

CO2: explore detailed study on different nonlinear phenomena and its applications

CO3: apply the knowledge for thirdharmonic conversion and evaluate nonlinear susceptibility of materials

CO4: illustrate about multiphonon process and kerr effect

CO5: explore about raman scattering process and its applications

Board of Studies (BoS) :
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Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO 2	PSO 3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHDY 107	OPTICAL FIBER COMMUNICATION	L	T	P	C
SDG: 4		2	0	2	3

COURSE OBJECTIVES:

COB1: To introduce the principles and classifications of fiber optic communication.

COB2: To introduce the various optical fiber modes, configurations and various signal degradation factors associated with optical fiber.

COB3: To analyze the different types of optical fiber cables and connectors.

COB4: To study about various optical sources and optical detectors and their use in the optical communication system.

MODULE I FIBER OPTICS 6

Introduction to optical fiber – structure of an optical fiber - Total internal reflection - Phase shift & attenuation during total internal reflection - Hybrid modes - cutoff frequencies - meridinal rays & skew rays – Classifications of optical fiber.

MODULE II TRANSMISSION CHARACTERISTICS OF OPTICAL FIBERS 7

Dispersion - Fiber attenuation, absorption loss & scattering loss measurement - Optical Time Domain Reflectometer (OTDR) and its uses - Interferometric method to measure fiber refractive index profile.

MODULE III OPTICAL FIBERS CABLES & CONNECTORS 7

Fiber materials - Fiber fabrication- fiber optic cables design - fiber connectors - fiber splices - Lensing schemes for coupling improvements.

MODULE IV MODULATION, OPTICAL SOURCES, DETECTION AND COMMUNICATION NETWORKS 10

Electrooptic and Acoustooptic modulation - Injection laser - Homojunction and Heterojunction lasers - Injection laser to fiber coupling - Fiber lasers - Surface Emitting, edge emitting and superluminescent LEDs - Optical Detectors - Pin photodiodes - Avalanche photodiodes - Multiplexers - wavelength division multiplexing - Elements of an optical fiber communication system - Coherent optical fiber communication system - Local Area Networks - Bus, ring and star topologies - optical fiber regenerative repeater - optical amplifiers - basic applications - Low speed industrial optical fiber networks

L-30; P – 30; TOTAL HOURS - 60

LIST OF EXPERIMENTS:

1. To measure the numerical aperture (NA) of the different optical fiber.
2. Measuring optical power attenuation in plastic optical fiber.
3. Measuring optical power bending loss and coupling loss in plastic optical fiber.
4. To check the VI characteristic of LED.
5. Characteristics of LASER Diode.
6. Characteristics of APD
7. Describe the operational characteristics and parameters of Photodiode used as photo detector in fiber optic system

REFERENCES:

1. Gerd Keiser, "Optical fiber Communications", McGraw Hill Inc. Company, Tokyo, 5th Edition, 2017.
2. John M. Senior, "Optical Fiber Communications", Prentice Hall International Ltd., London, 3rd Edition, 2010.
3. Govind P. Agrawal, "Fiber Optic Communication Systems", John Wiley & Sons Inc., New York, 3rd Edition, 2007.
4. Allen H. Cherin, "An Introduction to Optical Fibers", Mc Graw Hill Inc., Tokyo, 1995.

COURSE OUTCOMES

CO1: Design optimization of single mode fibers, refractive index profile and cut-off wavelength.

CO2: Know the various optical fiber modes, configurations and various signal degradation factors associated with optical fiber

CO3: Analyze the different types of optical fiber cables and connectors.

CO4: Understand various optical sources and optical detectors and their use in the optical communication system.

Board of Studies (BoS) :
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Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHEY 108	NANOSCIENCE AND TECHNOLOGY	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To enable students understand the general principles of nanomaterials.

COB2: To learn the different tools for characterization.

COB3: To get into Insight of the materials, fabrication and other experimental techniques that can be used on the nanoscale, as well as their limitations.

COB4: To get in-depth knowledge of at least one specialisation area within the field of nanoscience and nanotechnology.

COB5: To gain Sufficient scientific background to undertake research.

MODULE I NANOMATERIALS AND STRUCTURES 9

Nanomaterials and types: nanowires, nanotubes, fullerenes, quantum dots, nanocomposites – properties – Methods of preparation: top-down, bottom-up.

MODULE II CHARACTERIZATION TOOLS 9

Electron Microscopy Techniques – SEM, TEM, X ray methods – optical methods Fluorescence Microscopy – Atomic Force Microscopy, STM and SPM.

MODULE III NANOMAGNETISM 9

Mesoscopic magnetism – Magnetic measurements: miniature Hall detectors, integrated DC SQUID Microsusceptometry – magnetic recording technology, biological magnets.

MODULE IV NANOELECTRONICS AND INTEGRATED SYSTEMS 9

Basics of nanoelectronics – Single Electron Transistor – quantum computation– tools of micro-nanofabrication – nanolithography – quantum electronic devices – MEMS and NEMS – dynamics of NEMS – limits of integrated electronics.

MODULE V BIOMEDICAL APPLICATIONS OF NANOTECHNOLOGY 9

Biological structures and functions – drug delivery systems – organic-inorganic nanohybrids – inorganic carriers – nanofluidics.

L – 45; TOTAL HOURS –45

REFERENCES:

1. Jan Korvink and Andreas Greiner, Semiconductors for Micro and Nanotechnology – an Introduction for Engineers, Weinheim Cambridge: Wiley- VCH, 2001.
2. Murty B.S., Shankar P. & et al., Textbook of Nanoscience and Nanotechnology, Universities Press (India) Private Ltd., 2012.
3. Richard Booker and Earl Boysen, Nanotechlongy, Wiley Publishing, 2005.
4. Timp G (ed), Nanotechnology, AIP press, Springer, 1999.
5. Wilson M., Kannangara K., Smith G., Simmons M. and Raguse B., Nanotechnology: Basic Sciences and Energy Technologies, Overseas Press, 2005.

COURSE OUTCOMES:

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

CO1: the basic concepts of nanomaterials

CO2: working mechanism of various advanced characterization techniques

CO3: applications of nanomagnetism in advanced instruments

CO4: nanoelectronics towards MEMS applications.

CO5: the application of nanomaterials in biomedical field.

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

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19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PSO 2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHEY 109	LASER SPECTROSCOPY AND ITS APPLICATIONS	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To endow the students with the knowledge of the fundamentals of spectroscopy.

COB2: To learn the basics in high resolution spectroscopy

COB3: To understand the applications of laser spectroscopy in various fields.

COB4: To learn about the photobiology and medical lasers.

COB5: To understand the thermal and non-thermal applications of lasers.

MODULE I TIME-RESOLVED SPECTROSCOPY 9

Generation of short optical pulses - generation of ultra short optical pulses - Measurement techniques for Optical Transcients: Transient - Digitizer - Boxcar - Delayed coincidence- Streak-camera & Pump-probe techniques. Basics of lifetime measurements - Methods of measuring radiative properties – line width measurements - ODR and LC - Beam foil techniques - Beam laser techniques - Time resolved spectroscopy with pulsed lasers - Phase-shift method and emission method - The hook method - Quantum-Beat spectroscopy.

MODULE II HIGH RESOLUTION SPECTROSCOPY 9

Spectroscopy on collimated atomic beams: Detection through fluorescence - detection by photoionization - detection by the recoil effect detection by magnetic deflection. Saturation spectroscopy and related techniques - Doppler-free two-photon absorption - spectroscopy of trapped ions and atoms.

MODULE III APPLICATIONS OF LASER-SPECTROSCOPY 9

Diagnostics of combustion processes: Background - Laser-induced fluorescence and related techniques - Raman spectroscopy - coherent anti-stokes Raman scattering - Velocity measurements. Laser remote sensing of the atmosphere: Optical heterodyne detection – long path absorption techniques - LIDAR techniques. Laser- induced fluorescence and Raman spectroscopy in liquids and solids: Hydrospheric remote sensing - monitoring of surface layers. Laser-induced chemical processes: Laser-induced

chemistry - laser isotope separation - spectroscopic aspects of lasers in medicine.

MODULE IV PHOTOBIOLOGY AND MEDICAL LASERS **9**

Study of biological functions - Microradiation of cells - optical properties of tissues (normal and diseased state) - Experimental methods to determine the reflectance, absorption, transmittance and emission properties of tissues - Laser systems in medicine and biology - Nd: YAG, Ar ion, CO_2, Excimer, N_2, Gold Vapour laser - Beam delivery and measuring systems.

MODULE V THERMAL APPLICATIONS **9**

Surgical applications of lasers - Sterilization - hermostasis - Cancer Liver stomach gynecological surgeries - Performance evaluation - Lasers in Opthalmology - Dermatology and Dentistry - Cosmetic Surgery.

L – 45; TOTAL HOURS –45

REFERENCES:

1. S. Svanberg, "Atomic and Molecular Spectroscopy", Springer Verlag, Germany, 1992.
2. J. R. Lakowicz, "Principles of Fluorescence Spectroscopy", Kluwer Academic/ Plenum Publishers, New York, 1999.
3. Z. Wang and H. Xia, "Molecular and Laser Spectroscopy", Springer Series in Chemical Physics, Vol.50, 1991.
4. S.S. Martellucci and A.N. Chester, "Laser Photobiology and Photomedicine", Plenum Press, New York, 1985.
5. R. Pratesi and C.A. Sacchi, "Lasers in Photomedicine and Photobiology", Springer verlag, West Germany, 1980.
6. Carruth JAS & AL Mckenzie, "Medical Lasers Science and Clinical Practice", Adam Hilger Ltd., Bristol, 1991.
7. T. Kaluylu and M. Tsukakoshi, "Laser Microradiation of cells", Harward Academic publishers, New York, 1990.

COURSE OUTCOMES:

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

CO1: different types spectroscopy and applications of laser spectroscopy in various fields.

CO2: high resolution spectroscopy.

CO3: laser tissue interaction.

CO4: Thermal and non-thermal applications of lasers and safety of lasers.

CO5: Thermal and non-thermal applications of lasers and safety of lasers.

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

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CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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ELECTIVES - SEMESTER II

PHEY 201	**ELECTRO-OPTIC MATERIALS AND DEVICES**	**L**	**T**	**P**	**C**
SDG: 4		**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

COB1: To make the students to understand the various electro optic materials and devices.

COB2: To study the optical activity of crystals.

COB3: To understand the electro optic effect and its types

COB4: To understand the acousto optic and elasto optic effect

COB5: To study the application of non-linear optical materials

MODULE I PHYSICS OF LASER **9**

Laser beam characteristics, Spontaneous and stimulated emission - Population inversion - Threshold condition - Gain profile – super-radiance Laser - Rate equation for 3 level and 4 level systems - conditions for CW and pulsed laser action. Methods of detection and measurement of ultrashort pulses.

MODULE II OPTICAL ACTIVITY OF CRYSTALS **9**

Anisotropic media - index ellipsoid, propagation in uniaxial crystals, Birefringence, wave plates and compensators, optical activity.

MODULE III ELECTRO-OPTIC EFFECT **9**

E-O effect in KDP E-O retardation, E-O modulation - longitudinal and transverse E-O effect in cubic crystals, E-O Q- switching (Experimental) Beam deflectors.

MODULE IV ACOUSTO-OPTIC AND ELASTO-OPTIC EFFECTS **9**

Materials and devices based on these effects – modulators - SHG, mode locking and frequency mixing - materials and devices.

MODULE V NON LINEAR OPTICAL MATERIALS AND DEVICES **9**

Origin of optical nonlinearities – second and third order optical non-linearities- Optical switching devices employing optical non-linearities - Photorefractive effect - Two beam coupling in Photorefractive materials – Four wave mixing in

Photorefractive materials.

L – 45; TOTAL HOURS –45

REFERENCES:

1. Munn R W and Ironsid C N, "Non - Linear Optical Materials", Blackie Academic & Professional, Glassgow, 1993.
2. Kochner W, "Solid State Laser Engineering", Springer-Verlag, New York, 1976.
3. Yariv A, "Quantum Electronics", John Wiley & Sons, 1975.
4. Ivan P Kaminov, " Introduction to Electro-Optic Devices", Academic press, New York, 1974.

COURSE OUTCOMES:

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

- **CO1:** basics concepts in Laser
- **CO2:** optical activity of crystals such as anisotropic media, index ellipsoid, wave plates
- **CO3:** the concept of the electro-optic effect
- **CO4:** the basic of acoustic optic and elasto-optic effects
- **CO5:** non-linear optics and photorefractive effect

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

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CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

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PHEY 202	FERROELECTRIC MATERIALS AND DEVICES	L	T	P	C
SDG: 4		2	0	2	3

COURSE OBJECTIVES:

COB1: To enable the students understand the principles behind ferroelectric materials

COB2: To make the students understand materials, devices and applications

COB3: To understand the concept of dielectric materials

COB4: To get knowledge on application of ferroelectric materials towards fabrication of piezoelectric devices

MODULE I INTRODUCTION **8**

Maxwell equations – Polarization – Macroscopic electric field – Local electric field at an atom – Dielectric constant and polarizability – Structural phase transitions – Displacive transitions – Soft optical phonons – Landau theory of the phase transition– Second order transition – First order transition – Antiferroelectricity – Ferroelectric domains – Optical ceramics.

MODULE II THEORY OF FERROELECTRICS **8**

Ferroelectricity, piezoelectricity and pyroelectricity – definitions – classification of ferroelectrics – oxygen octahedral and order – disorder ferroelectronics. Characteristics of typical ferroelectrics, barium titanate, potassium dihydrogen phosphate and triglycine sulphate – applications of ferroelectrics. Theories of ferroelectrics – dipole theory of ferroelectrics– first order and second order transitions – ferroelectric domains.

MODULE III HIGH PERMITTIVITY DIELECTRICS **7**

Ceramic capacitors. Chip capacitors. Hybrid substrate– High permittivity – Diffuse phase transition – Dielectric relaxation -IK dielectric materials. Ferroelectric memory devices: DRAM – Ferroelectric DRAM Pyroelectric devices: Pyroelectric materials – pyroelectric effect – responsivity – figures of merit. Temperature / infrared light sensors.

MODULE IV PIEZOELECTRIC DEVICES **7**

Piezoelectric materials and properties – Figures of Merit. – Single crystal – polycrystalline materials - relaxer ferroelectrics polymers – composites thin films.

Pressure sensors, accelerometers, gyroscopes. Piezoelectric vibrators – ultrasonic transducers – Resonators/filters. Piezoelectric transformers, Piezoelectric actuators.

L – 30; P 30; TOTAL HOURS – 60

LIST OF EXPERMENTS

1. Determination of transition temperature of a ferroelectric material by hysteresis.
2. Determination of dielectric constant of ferroelectric material..
3. Modelling of Crystal structure of a ferroelectric material using DFT.
4. Determination of Band structure and Density of States of ferroelectric material
5. Determination of Curie constant of a ferroelectric material.

REFERENCES:

1. Kenji Uchino, “Ferroelectric Devices”, Marcel Dekker, INC, 2000.
2. Gerhard R, "Electrets", Vol 2, Laplacian Press, 2000.
3. Moulson A L and Herberh J M, "Electroceramics – Materials properties and Applications", Chapman & Hall, 2000.
4. Lines M E and Glass A M, "Principles and Applications of Ferroelectrics and Related Materials", Clarendon Press, 1977.
5. Jack C Burfoot, "Ferroelectrics – Introduction to the Physical Principles", D Van Nostrand Co., 1967.

COURSE OUTCOMES:

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

CO1: Understand the principles of ferroelectric materials.

CO2: Comprehend and analyze the basic theory behind the concept of ferroelectricity

CO3: Assimilate the concept of dielectric materials and apply its applications.

CO4: Comprehensively grasp ideas related to ferroelectric materials, devices and applications

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PS O3

CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 4 : Ensuring inclusive and equitable quality education for all persons and promote lifelong learning opportunities.

Statement : The modules and topics mentioned in this course are designed to ensure all inclusive and thorough education with equity to all persons and promote learning opportunities at all times.

PHEY 203	STRUCTURE AND PROPERTIES OF ALLOYS	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To enable the students understand importance of phase diagrams and their relationship with properties of alloys

COB2: To make the students understand the basic structure and property relationship of the alloy

COB3: To make students to learn the application of the alloys with respect to their phase diagram and properties

COB4: To study the characteristics of copper-zinc alloy

COB5: To study the characteristics of iron –carbon alloy

MODULE I SOLID SOLUTIONS 9

Concept of solid solution - Solid solutions of Copper and Iron - Cu-Ni phase diagram-cast cupro nickel microstructures - Properties of annealed copper solid solution alloys - Soft magnetic alloys - Stainless steels.

MODULE II EUTECTIC ALLOYS 9

Pb-Sb phase diagram and microstructure - Pb-Sn phase diagram - Cu:O system - Ternary Pb-Sn-Sb phase diagram -Characteristic properties of eutectic system alloys - Applications of Pb-Sn and Pb-Sn-Sb alloys

MODULE III CAST AND WROUGHT ALLOYS 9

Al-Si phase diagram - Al-Cu phase diagram -coherency theory of age hardneing - Microstructures – Cast aluminium alloy -properties-residual stresses and relaxation.

MODULE IV TWO PHASE ALLOYS 9

Cu-Zn phase diagram – Cu-Zn alloy structure - Cu-Sn and Cu-Al alloy systems and their microstructures - Properties of brasses, tin brasses and aluminium bronzes.

MODULE V IRON-CARBON ALLOYS 9

Fe-Fe3C phase diagram - Solubility of carbon in austenite and ferrite-terminology- Equilibrium and non equilibrium - Microstructures-properties of normalized steels - Grain size of steels - Engineering applications of low

carbon steels and low alloy high strength steels.

L – 45; TOTAL HOURS –45

REFERENCES:

1. Structure and Properties of Alloys, R.M.Brick and Arthur Philips, MCGraw Hill Book Co. inc, New york, 1985.
2. Solid State Physics - Structure and properties of materials, M.A.Wahab, Narosa publishing house, New Delhi, 2015
3. Heat Treatment - Principle and Techniques, T.V.Rajan, C.P.Sharma and Ashok Sharma, Prentice Hall of India pvt. Ltd., New Delhi, 1995.
4. Mateials Science and Processes, M.K.Muralidhara, Dhanpat Rai publishing company, New Delhi, 1998.
5. Charlie Brooks, R,Heat Treatment, Structure and properties of non ferrous alloys, American Society for Metals, U.S.A, 1984.
6. William F Smith, “Structure and Properties of Engineering Alloys”, McGraw– Hill, 2nd Edition,1993
7. William D. Callister, David G. Rethwisch,“Materials Science and Engineering : AN Introduction” Wiley Publishing, 9th Edition, 2013.

COURSE OUTCOMES:

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

CO1: understand the importance of phase diagrams and their relationship with properties of alloys

CO2: get insights into the basic structure and property relationship of the alloys

CO3: analyze the applications of phase diagram and their importance

CO4: create ideas about the application and characteristics of Cu-Zn alloy

CO5: holistically map the characteristics of iron-carbon alloy

Board of Studies (BoS) :
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Academic Council:
19th AC held on 29.09.2022

	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PS O2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHEY 204	PHOTONIC MATERIALS AND DEVICES	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To impart knowledge on photonic devices by going over the fundamentals of semiconductor physics and optical processes in semiconductors.

COB2: To study about various optical process in semiconductors

COB3: To explore device fabrication techniques using semiconductor materials

COB4: To gain knowledge on characteristics of photonic devices

COB5: To gain knowledge on photonic devices instruments

MODULE I SEMICONDUCTING MATERIALS 7

Band gaps - density of states – materials - optical and electronic properties carrier generation and recombination - mobility and diffusion - low dimensional structures - quantum wells - wires and dots - heterostructures.

MODULE II OPTICAL PROCESSES IN SEMICONDUCTORS 10

Electron-Hole formation and recombination – absorption in semiconductors – effect of electric field on absorption – absorption in quantum wells and the quantum-onfined Stark effect – Kramer-Kroning relations – radiation in semiconductors – deep level transitions – auger recombination – Luminescence from quantum wells – measurement of absorption and luminescence spectra – time resolved photoluminescence.

MODULE III SEMICONDUCTOR DEVICE FABRICATION 10

Types of photonic materials –III-V compound-II-VI compounds-Wafer preparation-interface quality- interdiffusion and doping. Quantum wells and bandgap engineering (examples of structures).Post-growth processing-Photolithography-different methodologies – patterning - fabrication of semiconductor devices.

MODULE IV PHOTONIC DEVICES 10

Cu-Zn phase diagram – Cu-Zn alloy structure - Cu-Sn and Cu-Al alloy systems and their microstructures - Properties of brasses, tin brasses and aluminium bronzes.

MODULE V INSTRUMENTATION OF PHOTONIC MATERIALS **8**

Fe-Fe3C phase diagram - Solubility of carbon in austenite and ferrite-terminology- Equilibrium and non equilibrium - Microstructures-properties of normalized steels - Grain size of steels - Engineering applications of low carbon steels and low alloy high strength steels.

L – 45; TOTAL HOURS –45

REFERENCES:

1. P. Bhattacharya, “Semiconductor optoelectronic devices”, Prentice-Hall India, New Delhi, 2003.
2. B.E.A. Saleh and M.C. Teich., “Fundamentals of photonics”, John Wiley.,New York, 1991.
3. J. Singh, “Optoelectronics: An introduction to materials and devices”, Mc- Graw-Hill Co., New York, 1996.
4. S.O. Kasap, “Optoelectronics and photonics: Principles and practices”,Prentice-Hall, New York, 2001.
5. T.P. Pearsall, “Photonics essentials: An introduction to experiments”, Mc- Graw-Hill Professional, New York, 2002.
6. Ajoy Ghatakand K Thyagarajan, “An Introduction on Fibre Optics”, Cambridge University Press, 2012.

COURSE OUTCOMES:

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

CO1: analyze the optical processes in semiconductors

CO2: understand the properties of a photonic materials.

CO3: get deeper insights into the photonic devices and its characterization techniques

CO4: explore about the characteristics of photonic devices

CO5: explain the instruments fabricated using photonic materials

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	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PS O2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

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PHEY 205	NUMERICAL METHODS AND PROGRAMMING	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To understand the basic errors occurring in numerical methods.

COB2: To have an idea about Algebraic and Transcendental Equations

COB3: To know about the interpolation concepts.

COB4: To familiarize the numerical differentiation and integration equations.

COB5: To learn about the C programming and its applications in the research areas.

MODULE I ERRORS AND THE MEASUREMENTS 9

Errors and their computations – General formula for errors – Errors of observation and measurement – Round of errors and Computer Arithmetic – Empirical formula – Graphical method – method of averages – Least square fitting – curve fitting – parabola, exponential – Algorithms and convergence.

MODULE II NUMERICAL SOLUTION OF ALGEBRAIC AND TRANSCENDENTAL EQUATIONS 9

The iteration method – the bisection method – the method of false position – Newton-Raphson method.SimultaneousLinear algebraic equations: Direct methods – Gauss elimination method – Gauss – Jordan method – Iterative method – Jacobi's method – Gauss Seidel iterative method.

MODULE III INTERPOLATION 9

Finite differences – Interpolation – Gregory – Newton forward interpolation of Newton's formula – Backward differences – Newton's Backward interpolation formula – central differences – Gauss's forward and backward formula – Stirling's formula – Divided differences – Newton's divided difference formula – Lagrange's interpolation formula.

MODULE IV NUMERICAL DIFFERENTIATION AND INTEGRATION 9

Introduction – Numerical differentiation – Errors in numerical differentiation – The cubic spline method – Maximum and Minimum values of a tabulated function – Numerical integration – Trapezoidal rule – Simpson's rule – Extended Simpson's rule – Use of cubic splines – Romberg integration – Newton – Cotes

Integration formulae– Euler – Maclaurin formula – Adaptive quadrature method – Gaussian integration.

MODULE V PROGRAMMING WITH C 9

Introduction to C programming-program control-logical compares-functions, variables and prototypes-C preprocessor- strings, arrays-pointers- standard input & output- structures, Unions-bitwise operators.

L – 45; TOTAL HOURS –45

REFERENCES:

1. Sastry, S.S., Introduction of Numerical Analysis, Fifth Edition, Prentice Hall of India, New Delhi, 2012.
2. Gerald C.F., Wheatley P.O., Applied Numerical Analysis, Seventh Edition, Addison – Wesley, Singapore, 2003.
3. Kandasamy, P., Thilakavthy, K and Gunavathy K., Numerical Methods, S.Chand and Co., New Delhi, 2006.
4. Grewal B.S., Grewal J.S., Numerical Methods in Engineering and Science, Khanna Publishers, New Delhi, 2015.
5. Balagurusamy. E, Programming in Ansi C, 7th Edition, Tata McGraw Hill, 2017.

COURSE OUTCOMES:

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

CO1: familiarize towards the approach in solving errors in numerical methods.

CO2: get deeper insights towards various numerical methods to solve the algebraic and transcendental equations.

CO3: explore towards Newton's Gregory forward interpolation

CO4: to solve differentiation and integration equations using numerical methods

CO5: approach the numerical problems using C programming

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CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHEY 206	ULTRASONIC AND NON-DESTRUCTIVE TESTING	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To introduce students with the recent advances in the field of ultrasonics

COB2: To equip them with the knowledge of different inspection methods.

COB3: To introduce the other NDT techniques like LPI to equip the students to understand the evaluation method

COB4: To understand the theory of wave guides and applications

COB5: To study the detection mechanism of ultrasonic sounds

MODULE I FUNDAMENTALS OF ULTRASONIC WAVES 9

Nature of sound waves, wave propagation in metals– modes of sound wave generation – longitudinal waves, transverse waves, surface waves, lamb waves – Velocity, frequency and wavelength of ultrasonic waves – Ultrasonic pressure, intensity and impedance – Attenuation of ultrasonic waves – reflection, refraction and mode convection – Snell's law and critical angles – Fresnel and Fraunhofer effects – ultrasonic beam split – wave propagation in other engineering materials.

MODULE II ULTRASONIC INSPECTION METHODS AND EQUIPMENT 9

Principle of pulse echo method, through transmission method, resonance method – Advantages, limitations – contact testing, immersion testing, couplants – Data presentation A, B and C scan displays, comparison of contact and immersion method. Pulse Echo instrumentation, controls and circuits, pulse generation, signal detection, display and recording methods, gates, alarms and attenuators, detectability of defects

MODULE III ULTRASONIC GUIDED WAVES 9

Types of guided waves – Generation of guided waves – Plate theory – Rayleigh-Lamb Equation, Guided waves in Plates, Pipes and rods – Wave structure analysis – Dispersion curves –Modes in guided waves – Air coupled ultrasonic guided waves – advantages and limitations – Applications, few case studies. Electro Magnetic Acoustic Transducer (EMAT)-Basic principles – types of coil and design – Generation and defect detection of guided waves using EMATS-- advantages and limitations – Applications- case studies

MODULE IV OPTICAL METHODS IN ULTRASONICS 9

Laser Ultrasonics – Laser fundamentals – types of lasers – bulk wave and lamb wave generation mechanisms – optical detection of ultrasound – measurement of in plane displacement and velocity – holographic NDT – recording and reconstruction of a hologram – Two wave mixing interferometry – Laser shearography – Applications (Laser ultrasonics for flaw detection and material characterization) – Case studies

L – 45; TOTAL HOURS –45

REFERENCES:

1..J. Krautkramer and H. Krautkramer, Ultrasonic Testing of Materials, Springer, 4 th edition (1990).

1. B. Raj, C.V. Subramanian and T. Jayakumar, Non Destructive Testing of Welds, Woodhead Publishing, 1st edition (2000).
2. L. Schmerr and J. Song, Fundamentals of Ultrasonic Nondestructive Evaluation, Springer, 1998.
3. P. J. Shull, Nondestructive Evaluation: Theory, Techniques, and Applications, CRC Press, 1st edition (2002).
4. C.V.Subramanian, Practical Ultrasonics, Alpha Science International, (2006).
5. A.S. Birks and R.E. Green, Ultrasonic Testing, Nondestructive Handbook, Vol. 7, American Society for Nondestructive Testing, 2nd edition (1991). York, 2002.
6. Rangan Sharma and Mani, “Instrumentation devices and systems”, Tata McGraw-Hill, New Delhi, 2000.

COURSE OUTCOMES:

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

- **CO1:** have a thorough understanding of basics of ultrasonic.
- **CO2:** Learn testing and NDT methods to enable them to perform inspection of samples.
- **CO3:** Understand ultrasonic guided waves in instrumentation.
- **CO4:** Differentiate various defect types and select the appropriate NDT methods for the specimen
- **CO5:** Compare different processes involved in the LPT.

Board of Studies (BoS) : BOS of Physics was held on 30.6.22

Academic Council: 19th AC held on 29.09.2022

	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PS O2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHEY 207	OPTO ELECTRONICS DEVICES	L	T	P	C
SDG: 4		2	0	2	3

COURSE OBJECTIVES:

COB1: To make the students learn about the fundamentals of Photo-luminous-semiconductors, Optoelectronic devices, Optical modulators/detectors

COB2: To make them understand the technology behind latest Display devices like LCD, Plasma and LED Panels.

COB3: To make students understand the various types of optical modulators and detectors

COB4: To get knowledge on photonic devices such as solar cells and photoconductors

MODULE I INTRODUCTION TO OPTOELECTRONIC MATERIALS 7

Energy bands in solids, Electrical conductivity, Semiconductors, carrier concentrations, Work function, Excess carrier in semiconductors, Junctions, , Metal- semiconductor junctions - semiconductor junctions: energy-band relation, surface states and depletion layer, Schottky-effect current transport process – thermo ionic emission, tunneling, device structures.

MODULE II OPTOELECTRONIC DEVICES 8

Light-Emitting Diodes, Semiconductor Lasers, Optical processes in semiconductor lasers - power and efficiency - double hetero LED - LED structure - LED characteristics - White LED – Applications.

MODULE III OPTICAL MODULATORS & DETECTORS 7

Modulation of light – birefringence - electro optic effect - EO materials - Kerr modulators - scanning and switching - self electro optic devices - MO devices, AO devices - AO modulators-Photo detectors - thermal detectors – photoconductors – detectors - photon devices - PMT- photodiodes - photo transistors - noise characteristics - PIN diode- APD characteristics - APD design of detector arrays – CCD

MODULE IV PHOTONIC DEVICES 8

Photoconductors – Solar cells – basic principles, spectral response, efficiency, materials and cascaded solar cells, thin film solar cells, manufacturing and design characteristics.

L – 30; P-30; TOTAL HOURS – 60

LIST OF EXPERMENTS

1. Characteristics of LEDs
2. Characteristics of LASER diode
3. Characteristics of Photodiodes
4. Characteristics of Solar cells
5. Determination of electro-optic coefficient using KERR modulator.
6. Characteristics of Diodes

REFERENCES:

1. Wilson & J.F.B. Hawkes, “Optoelectronics – An Introduction”, Prentice Hall, India, 1998.
2. Bhattacharya, “Semiconductor optoelectronic devices”, Second Edn Pearson Education, Singapore, 2002.
3. J. M. Senior, “Optical fiber communication”, Prentice-Hall India, 2009.
4. J. Gowar, “Optical fiber communication systems”, Prentice–Hall, 1995.
5. J .Palais, “Introduction to optical electronics”, Prentice–Hall, 1988.
6. Jasprit Singh, “Semiconductor optoelectronics”, McGraw–Hill, Inc, 1995.R. P.
7. Khare, “Fiber optics and Optoelectronics”, Oxford University Press, 2004.

COURSE OUTCOMES:

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

CO1: Understand the concept and theory on semiconductor devices

CO2: Analyse the concepts of light emitting diodes (LEDs) and Laser drive circuits.

CO3: Comprehend thoroughly the principles of modulation of light, birefringence, MO devices, the working of optical detectors and various optical devices.

CO4: Compare working mechanism of solar cells, efficiency calculation and large scale solar cells manufacturing technology

Board of Studies (BoS) :
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	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PS O2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHEY 208	BIOPHOTONICS	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To know the role of light and its interaction in the cells and tissues.

COB2: To understand the different imaging techniques for the biological systems.

COB3: To know the concepts of spectroscopy in biological applications.

COB4: To understand the optical force spectroscopy.

COB5: To understand the role of Biophotonic materials in applications.

MODULE I INTERACTION OF LIGHT WITH BIOLOGICAL SYSTEMS 9

Interaction of light with cells, tissues, nonlinear optical processes with intense laser beams, photo-induced effects in biological systems.

MODULE II IMAGING TECHNIQUES 9

Imaging techniques: Light microscopy, wide-field, laser scanning - confocal, multiphoton, fluorescence lifetime imaging, FRET imaging - Frequency-Domain lifetime imaging. Cellular Imaging - Imaging of soft and hard tissues and other biological structures.

MODULE III SINGLE MOLECULE SPECTROSCOPY 9

Single molecule spectroscopy: UV-VIS spectroscopy of biological systems, single molecule spectra and characteristics – IR and Raman spectroscopy and Surface Enhanced Raman Spectroscopy for single molecule applications.

MODULE IV OPTICAL FORCE SPECTROSCOPY 9

Optical Force Spectroscopy: Generation optical forces – Optical trapping and manipulation of single molecules and cells in optical confinement - Laser trapping and dissection for biological systems - single molecule biophysics, DNA protein interactions.

MODULE V BIOSENSORS 9

Biosensors, Principles- DNA based biosensors – Protein based

biosensors– materials for biosensor applications- fabrication of biosensors.

L – 45; TOTAL HOURS –45

REFERENCES:

1. Prasad. P.N., Introduction to Biophotonics, John Wiley & Sons, 2003
2. Michael P. Sheetz, Laser Tweezers in Cell Biology (Methods in Cell Biology), Vol.55, Academic Press Publishers, 1997.
3. Ranier .W, Nanoelectronics and Information Technology, Wiley Publishers, 2012.
4. Drexler. K.E., Nanosystems: Molecular Machinery, Manufacturing and Computation, Wiley Publishers, 1992.

COURSE OUTCOMES:

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

CO1: Make clear insights into the applications of light interaction with biological systems.

CO2: Compare different imaging techniques

CO3: Understand and analyse the various spectroscopic techniques used in biological system.

CO4: Effectively grasp the usage of the optical force spectroscopy.

CO5: Get clear ideas and communicate about the importance of use of spectroscopy in design of bio-photonic devices.

Board of Studies (BoS) : BOS of Physics was held on 30.6.22

Academic Council: 19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PS O2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHEY 209	CHAOS, SOLITONS AND FRACTALS	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To introduce the concept of dynamical systems, phase-space and equilibrium points.

COB2: To make the students to understand the importance of nonlinearity and bifurcations.

COB3: To show the occurrence of chaos in discrete systems and applications.

COB4: To elucidate the notion of fractals and pattern formation in dynamical systems.

COB5: To introduce the concepts of solitons in simple non linear dynamical systems.

MODULE I DYNAMICAL SYSTEMS 9

Linear and nonlinear differential equations - Autonomous and nonautonomous systems - Phase trajectories, phase-space, flows and limit sets – Linear systems and linearity principle – Second- order linear equations – Trace-Determinant plane - Classification of equilibrium points in planar systems – Periodic orbits, limit cycles, Poincaré-Bendixson theorem.

MODULE II BIFURCATIONS AND CHAOS 9

Equilibria in nonlinear systems - bifurcations – Local and global bifurcations - Three dimensional autonomous systems and chaos, Lyapunov exponents -– Torus – quasi-periodic attractor – Poincaré map – Period doubling cascades – Feigenbaum number – intermittency route to chaos - characterization – Homoclinic orbits, heteroclinic orbits – Strange attractor and strange non-chaotic attractor – experimental observation of chaos.

MODULE III DISCRETE DYNAMICAL SYSTEMS AND SYNCHRONIZATION 9

Linear and nonlinear discrete dynamics systems – complex iterated maps – Logistic map – Linear stability – occurrence of chaos – volume preserving maps – coupled maps – spatio-temporal dynamics - Chaos synchronization – Synchronization manifold and stability properties – Controlling of Chaos – applications.

MODULE IV FRACTALS AND PATTERN FORMATION 9

Dimension of regular and chaotic attractors – Fractals – Koch curve – Cantor set – Sierpinski set – Julia and Mandelbrot sets – Cellular automata – Self organized criticality – Stochastic resonance – pattern formation – Time series analysis.

MODULE V SOLITONSYSTEMS 9

Finite dimensional integrable systems - Linear and nonlinear dispersive systems – solitary waves - The Scott Russel phenomenon and derivation of Korteweg-de Vries (KdV) equation – Fermi – Pasta – Ulam (FPU) numerical problem – FPU recurrence phenomenon – Numerical experiments of Zabusky and Kruskal – Explicit soliton solutions: one-, two- and N- soliton solutions of KdV equation – Hirota's bilinear method – soliton oscillators.

L – 45; TOTAL HOURS –45

REFERENCES:

1. M. Lakshmanan and S. Rajasekar. Nonlinear Dynamics: Integrability Chaos and Patterns. Springer-Verlag, Berlin, 2003.
2. M. Lakshmanan and K. Murali. Chaos in Nonlinear Oscillators. World Scientific, Singapore,1996
3. S. H. Strogatz. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering. Taylor & Francis, 2014.
4. J.M.T.Thompson and H.B.Stewart. Nonlinear Dynamics and Chaos. Wiley, 2013.
5. D.D.Nolte. Introduction to Modern dynamics: Chaos, networks, space and time. Oxford University Press, 2015.
6.

COURSE OUTCOMES:

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

CO1: Understand the concept of dynamical systems, phase-space and equilibrium points.

CO2: Appreciate the importance of nonlinearity and bifurcations in dynamical systems.

CO3: Investigate the chaotic dynamics in discrete systems.

CO4: Know the aspect of fractals and pattern formation in dynamical systems.

CO5: Analyse the requirements needed to observe solitons in simple nonlinear dynamical systems.

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

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19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PS O2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 4 : Ensuring inclusive and equitable quality education for all persons and promote lifelong learning opportunities.

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ELECTIVES - SEMESTER III

PHEY 301	**MATHEMATICAL METHODS FOR**	**L**	**T**	**P**	**C**
SDG: 4	**NONLINEAR SCIENCE**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

COB1: To understand the basic concepts of different mathematical methods useful for nonlinear sciences.

COB2: To provide the basics of nonlinear ordinary and partial differential equations

COB3: To study discrete Fourier transform method to solve nonlinear systems

COB4: To have a comprehensive idea on KdV and NLS soliton equations.

COB5: To understand the Inverse scattering, Backlund transformations and Hirota's method to solve the integrable systems.

MODULE I FOURIER ANALYSIS AND OPTICS 9

Fourier series – Harmonic analysis – Fourier Transform and applications – Convolution Theorem – Sampling Theorem and applications – Fourier Optics-Holographic filters.

MODULE II TRANSDUCERS 9

Classification of Transducers - Principle, construction and working of Thermistor - LVDT, Electrical strain gauges and capacitive transducers, Photoelectric transducer, Piezoelectric transducer - Measurement of non-electrical quantities - Strain, Displacement, temperature, Pressure, Magnetic fields, vibration, optical and particle detectors.

MODULE III BRIDGES AND RECORDERS 9

DC bridges - Wheatstone's bridge – Kelvin's bridge – double bridge –AC bridges – bridges for capacitance and inductance comparison – Wien bridge – Schering bridge

– Maxwell's inductance bridge – Maxwell – Wein bridge - Hay bridge – Anderson bridge – De sauty bridge – Owen bridge - resonance bridge – types of detectors– strip chart recorders – X-Y recorders – digital data recording – recorder specifications.

MODULE IV INSTRUMENTATION ELECTRONICS 9

Op-amps – instrumentation amplifier – signal conditioning – filters – analog signal processing – high speed A/D conversion – D/A conversion – digital logic levels –

digital instrumentation – frequency measurements – FFT –sampling time and analyzing – IEEE 488 interface bus – LabView (basics).

MODULE V ADVANCED MEASUREMENTS 9

Spectroscopic instrumentation –UV – Vis spectrometer IR spectroscopy – spectrometer design – refraction and diffraction — dispersive elements – lasers – fiber optics – X-ray fluorescence: line spectra and fine structure – absorption and emission processes – X-ray production – X-ray crystallography –neutron diffraction – TEM – SEM – atomic force and tunneling scanning microscope.

L – 45; TOTAL HOURS –45

REFERENCES:

1. M. Sayer and A. Mansingh, “Measurement, instrumentation and experiment design in physics and engineering”, Prentice-Hall India Pvt. Ltd., New Delhi,2000.
2. H.S. Kalsi, ‘Electronic instrumentation’, (2nd Edition), Tata McGraw Hill Publication Co.Ltd., New Delhi, 2004.
3. R.F. Coughlin and F.F. Driscoll, “Operational amplifiers and linear integrated circuits”, Pearson Education, New Delhi, 2001.
4. E.O. Doebelin, “Measurement systems: Applications and design”, McGraw-Hill, New York, 2002.
5. Rangan Sharma and Mani, “Instrumentation devices and systems”, Tata McGraw-Hill, New Delhi, 2000.

COURSE OUTCOMES:

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

CO1: acquire the knowledge about the different errors and principle behind the instrumentation for measurement.

CO2: gain knowledge about bridges and recorders used in instrumentation techniques.

CO3: interaction of radiation with matter.

CO4: Apply the knowledgegained in electronic devices for instrumentation techniques.

CO5: Identify the different advanced measuring instruments for practical applications.

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
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CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHEY 302	MEASUREMENT AND INSTRUMENTATION	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To enable the students understand the importance of measurements.

COB2: To make the students understand the principle behind the transducers

COB3: To understand different types of bridges and recorders used in instrumentation techniques.

COB4: To understand different types of electronic devices used in instrumentation techniques.

COB5: To learn about the different advanced measuring instruments.

MODULE I PHYSICAL MEASUREMENT 9

Measurement – result of a measurement – uncertainty and experimental error– systematic error – random error – repeated measurements – data distribution functions; mathematical description, derivation and properties- propagation error – analysis of data – multi parameter experiments.

MODULE II TRANSDUCERS 9

Classification of Transducers - Principle, construction and working of Thermistor - LVDT, Electrical strain gauges and capacitive transducers, Photoelectric transducer, Piezoelectric transducer - Measurement of non-electrical quantities - Strain, Displacement, temperature, Pressure, Magnetic fields, vibration, optical and particle detectors.

MODULE III BRIDGES AND RECORDERS 9

DC bridges - Wheatstone's bridge – Kelvin's bridge – double bridge –AC bridges – bridges for capacitance and inductance comparison – Wien bridge – Schering bridge – Maxwell's inductance bridge – Maxwell – Wein bridge - Hay bridge – Anderson bridge – De sauty bridge – Owen bridge - resonance bridge – types of detectors– strip chart recorders – X-Y recorders – digital data recording – recorder specifications.

MODULE IV INSTRUMENTATION ELECTRONICS 9

Op-amps – instrumentation amplifier – signal conditioning – filters – analog signal processing – high speed A/D conversion – D/A conversion – digital logic levels – digital instrumentation – frequency measurements – FFT –sampling time and

analyzing – IEEE 488 interface bus – LabView (basics).

MODULE V ADVANCED MEASUREMENTS 9

Spectroscopic instrumentation –UV – Vis spectrometer IR spectroscopy – spectrometer design – refraction and diffraction –– dispersive elements – lasers – fiber optics – X-ray fluorescence: line spectra and fine structure – absorption and emission processes – X-ray production – X-ray crystallography –neutron diffraction – TEM – SEM – atomic force and tunneling scanning microscope.

L – 45; TOTAL HOURS –45

REFERENCES:

1. M. Sayer and A. Mansingh, “Measurement, instrumentation and experiment design in physics and engineering”, Prentice-Hall India Pvt. Ltd., New Delhi,2000.
2. H.S. Kalsi, ‘Electronic instrumentation’, (2nd Edition), Tata McGraw Hill Publication Co.Ltd., New Delhi, 2004.
3. R.F. Coughlin and F.F. Driscoll, “Operational amplifiers and linear integrated circuits”, Pearson Education, New Delhi, 2001.
4. E.O. Doebelin,“Measurement systems: Applications and design”, McGraw-Hill,New York, 2002.
5. Rangan Sharma and Mani, “Instrumentation devices and systems”, Tata McGraw-Hill, New Delhi, 2000.

COURSE OUTCOMES:

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

CO1: acquire the knowledge about the different errors and principle behind the instrumentation for measurement.

CO2: gainknowledge about bridges and recorders used in instrumentation techniques.

CO3: interaction of radiation with matter.

CO4: Apply the knowledge gained in electronic devices for instrumentation techniques.

CO5: Identify the different advanced measuring instruments for practical applications.

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CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

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PHEY 303	BIOMEDICAL INSTRUMENTATION	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To understand the human physiological systems.

COB2: To know the different aspects of biosignal acquisition.

COB3: To understand the basics in biopotential recorders.

COB4: To know the importance methods, instruments available for biomedical field.

COB5: To analyze the special biomedical instrumentation systems.

MODULE I HUMAN PHYSIOLOGICAL SYSTEMS 9

Cells and their structure – Nature of Cancer cells – Transport of ions through the cell membrane – Resting and action potentials – Bio-electric potentials – Nerve tissues and organs – Different systems of human body. Biopotential Electrodes and Transducers Design of Medical instruments – components of the biomedical instrument system – Electrodes – Transducers.

MODULE II BIOSIGNAL ACQUISITION 9

Physiological signal amplifiers – Isolation amplifiers – Medical preamplifier design – Bridge amplifiers – Line driving amplifier – Current amplifier – Chopper amplifier – Biosignal analysis – Signal recovery and data acquisition – Drift Compensation in operational amplifier – Pattern recognition – Physiological Assist Devices. Pacemakers – Pacemakers batteries – Artificial heart valves – Defibrillators – nerve and muscle stimulators Heart – Lung machine – Kidney machine.

MODULE III BIOPOTENTIAL RECORDERS 9

Characteristics of the recording system – Electrocardiography (ECG) – Electroencephalography (EEG) – Electromyography (EMG) – Electroethinogrphy (ERG) and Electroculography (EOG) – Recorders with high accuracy – recorders for OFF line analysis.

MODULE IV OPERATION THEATRE EQUIPMENT 9

urgical diathermy- shortwave diathermy – Microwave diathermy – Ultrasonic disathermy – Therapeutic effect of heat – Range and area of irritation of different techniques – Ventilators – Anesthesia machine – Blood flowmeter –

Cardiac Output measurements – Pulmonary function analyzers – Gas analyzers – Blood gas analyzers – Oximeters – Elements of intensive care monitoring.

MODULE V SPECIALISED MEDICAL EQUIPMENTS 9

Blood Cell counter – Electron microscope – Radiation detectors – Photometers and colorimeters – digital thermometer – audiometers – X-rays tube – X-ray machine – image intensifiers – Angiography – Application of X-ray examination. Safety instrumentation: Radiation safety instrumentation – Physiological effects due to 50Hz current passage – Microshock and macroshock – electrical accident Hospitals – Devices to protect against electrical hazards – Hospitals architecture.

L – 45; TOTAL HOURS –45

REFERENCES:

1. Arumugam M., Biomedical Instrumentaion, Anurada Agencies Publishers, 1992.
2. Khandpur R.S., Handbook of Biomedical Instrumentation, Third Edition, Tata McGraw-Hill Education, 2014.
3. Shakti Chatterjee and Aubert Miller, Biomedical Instrumentation Systems, Cengage Learning Publisher, 2010.
4. Gromwell L., Fred J. Weibell, Erich A. Pfeiffer, Biomedical Instrumentation and Measurements, Second Edition, Prentice Hall, 1980.

COURSE OUTCOMES:

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

- **CO1:** the human physiological systems.
- **CO2:** the different aspects of biosignal acquisition.
- **CO3:** different biopotential recorders such as EEG, ECG, EMG, EOG
- **CO4:** biomedical instruments involved in advanced operation theatres
- **CO5:** the application of biomaterials towards specialized medical equipment such as electron microscope and radiation detectors

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHEY 304	RADIATION PHYSICS	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To understand the theory of electromagnetic radiation.

COB2: To know the difference between natural and artificial radioactivity

COB3: To understand the effect of radiation factors.

COB4: To study the interaction of radiation with matter and its effects.

COB5: To understand the interaction of charged particles with matter.

MODULE I ELECTROMAGNETIC RADIATION 9

Wave model – Quantum Model– visible light and fluorescence particulate radiation – inverse square law

MODULE II NATURAL AND ARTIFICIAL RADIOACTIVITY 9

Radioactivity – General properties of alpha, beta and gamma rays – Laws Of radioactive disintegration – Radioactive decay constant – Half-life period – average life – Isotopes, Isobars, Isomers – Isotones and Isodiapheres – Natural radioactive series – Radioactive equilibrium –Radioactive decay - a particle decay – ß particle decay – Theory of beta decay – Gamma emission – Electron capture – Internal conversion – Nuclear isomerism – Artificial radioactivity - Nuclear reactions –a, p reaction - a, n reaction-Proton bombardment – deuteron bombardment- neutron bombardment – photo disintegration – Activation of nuclides - Elementary ideas of fission, fusion and nuclear reactors.

MODULE III RADIATION FACTORS 9

Quantities to describe a radiation beam - particle flux and fluence- Photon flux and fluence- cross section- linear and mass absorption coefficient-stopping power and LET Activity – Curie – Becquerel. Exposure and its measurements – Roentgen, Radiation absorbed Dose- Gray - kerma- kerma rate constant - Electronic equilibrium relationship between kerma, exposure and absorbed dose – Relative biological effectiveness (RBE)- radiation weighting factors.

MODULE IV INTERACTION OF RADIATION WITH MATTER 9

Interaction of electromagnetic radiation with matter: Ionization – Photon beam

exponential attenuation – Rayleigh scattering – Photoelectric effect – Compton effect- - energy absorption – Pair production – Attenuation, energy transfer and mass energy absorption coefficients – Relative importance of various types of interactions.

MODULE V INTERACTION OF CHARGED PARTICLES WITH MATTER **9**

Classical theory of inelastic collisions with atomic electrons – Energy loss per ion pair by primary and secondary ionization – Dependence of collision energy losses on the physical and chemical state of the absorber – Cerenkov radiation – Electron absorption process – scattering excitation and ionization – Radiative collision – Bremmstrahlung – Range energy relation – Continuous slowing down approximation (CSDA) – straight ahead approximation and detour factors – transmission and depth dependence methods for determination of particle penetration - empirical relations between range and energy – Back scattering.

L – 45; TOTAL HOURS –45

REFERENCES:

1. Segre E., Experimental Nuclear Physics, Vol 3, John Wiley, 1959.
2. Theraja B.L., Modern Physics, S.Chand Company, 1995.
3. Faiz M Khan , The Physics of Radiation Therapy, Lippincott Williams & Wilkins Publishers, 2010.
4. Oliver R., Radiation Physics in Radiology, Blackwell Scientific Publication, 1974.
5. Frank Herbert Attix, Introduction to Radiological Physics and Radiation Dosimetry, Wiley-VCH Publishers, 1991.

COURSE OUTCOMES:

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

CO1: concepts of electromagnetic radiation.

CO2: theory of artificial and natural radioactivity

CO3: interaction of radiation with matter.

CO4: the interaction of radiation with matter and its effects.

CO5: charged particles interaction with matter.

Board of Studies (BoS) :
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CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHEY 305	DENSITY FUNCTIONAL THEORY	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To understand the Density Functional Theory in Functional and derivatives

COB2: To solve the Many body problems using DFT.

COB3: To understand the Local & semi Local Approximations.

COB4: To solve Kohn-Sham equation

COB5: To understand the applications of DFT

MODULE I INTRODUCTION TO MANY ELECTRON PROBLEMS 9

Hartree Fock (HF) theory- Configuration Interaction (CI) - Practical difficulties in solving many electron problems - The Thomas Fermi model: precursor to modern DFT - Functional and functional derivatives, Euler Lagrange equation - Hohenberg KohnTheorem - N and v represent ability of densities, and non uniqueness of potentials.

MODULE II KOHN SHAM (KS) EQUATION 9

Effective exact single particle method to the many body problems - Exchange and correlation energies - Interpretation of KS Eigen values: Koopman's theorem, Ionization energy, Fermi surface, band gap KS equation for spin polarized systems.

MODULE III APPROXIMATION TO FUNCTIONALS 9

Local approximation: local density approximation (LDA) – Semi local approximation: generalized gradient approximation (GGA) –Hubbard Model-applying GGA+U methods- Non local approximation: hybrid functional - Self interaction correction.

MODULE IV DENSITY FUNCTIONAL THEORIES 9

Introduction - Green's Function and Self-energy Operator - any-Body Perturbation Theory and the *GW* Approximation - Pathologies of the Kohn–Sham xc Functional - The Band Gap Problem - Widely Separated Open Shell Atoms - The Exchange-Correlation Electric Field - Total Energies from Many-Body Theory – Applications - Generalised KS Schemes and Self-energy Models

MODULE V PRACTICAL IMPLEMENTATION OF DFT METHODS 9

General scheme for solving Kohn Sham equation - Full potential and pseudo

potential methods - Basis functions: Gaussian, LAPW, Numerical – Application of DFT methods for molecules and solids- vibrational frequencies, enthalpy, and Gibbs free energy of molecules.

L – 45; TOTAL HOURS –45

REFERENCES:

1. Density Functional Theory of Atoms and Molecules by Robert G. Parr and Yang Weitao, Publisher: Oxford University Press (1994).
2. Density Functional Theory: An Advanced Course by Eberhard Engel and Reiner M. Dreizle, Publisher: Springer, 2011 edition.
3. Electronic Structure: Basic Theory and Practical Methods by Richard M.Martin, Publisher: Cambridge University Press; 1 edition (2008).
4. Density Functional Theory: A Practical Introduction by David Sholl and Janice A Stecke, Publisher: WileyInterscience; 1 edition (2009).

COURSE OUTCOMES:

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

CO1: Identify the difference between Hartree and Hartree Fock theorems.

CO2: explain the basic concepts in many body problems.

CO3: understand the basics of Kohn-Sham equations.

CO4: interpret the various exchange-correlation schemes.

CO5: apply theorems relating to the DFT to real problems.

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CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHEY 306	NANOPHOTONICS	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To understand basic concepts of Nano Photonics.

COB2: To know the importance of nanophotonics materials.

COB3: To understand concept of Plasmonics.

COB4: To know electronics and photonic molecular materials and its applications

COB5: To understand the application of plasmonics

MODULE I BASIC OF PHOTONICS 9

Similarities and differences between photon and electron- Free- Space propagation. Co-operative effects and confinement of Photons and Electrons. Maxwell equation for Photonic systems. Concept of near-field phenomena in photonics crystals. Band structures of photonics crystal. Optical properties of photonics materials. Confinement in 1-D, 2-D and 3-D structure.

MODULE II NEW APPROACHES IN NANOPHOTONICS 9

Near-Field Optics- Aperture near-field optics- Apertureless near-field optics-Near-field scanning optical microscopy (NSOM or SNOM)- SNOM based detection of plasmonic energy transport- SNOM based visualization of waveguide structures- SNOM in nanolithography- SNOM based optical data storage and recovery.

MODULE III PLASMONICS 9

Blood clotting – Blood rheology – Blood vessels – The heart – Aorta and valves – Geometry of blood circulation – The lungs - Vascular implants: vascular graft, cardiac valve prostheses, cardiac pacemakers – Blood substitutes – Extracorporeal blood circulation devices.

MODULE IV PLASMONICS 9

Internal reflection and evanescent waves- plasmons and surface plasmon resonance (SPR)- Attenuated total reflection- Grating SPR coupling- Optical waveguide SPR coupling- SPR dependencies and materials- plasmonics and nanoparticles.

MODULE V ELEMENTS OF PLASMONICS AND APPLICATIONS 9

Introduction to Plasmonics, merging photonics and electronics at nanoscale dimensions, single photon transistor using surface plasmon, nanowire surface plasmons-interaction with matter, single emitter as saturable mirror, photon correlation, and integrated systems. All optical modulation by plasmonic excitation of quantum dots, Channel plasmon-polariton guiding by subwavelength metal grooves, Near-field photonics: surface plasmon polaritons and localized surface plasmons, Slow guided surface plasmons at telecom frequencies.

L – 45; TOTAL HOURS –45

REFERENCES:

1. Masuhara. H, Kawata. S and Tokunaga. F, Nano Biophotonics, Elsevier Science, 2014.
2. Saleh. B.E.A and Teich. A.C, Fundamentals of Photonics, John-Wiley & Sons, New York, 2014.
3. Ohtsu.M, Kobayashi.K, Kawazoe.T and Yatsui.T, Principles of Nanophotonics (Optics and Optoelectronics), University of Tokyo, Japan, 2013.
4. Joannopoulos.J.D, Meade. R.D and Winn. J.N, Photonic Crystals, Princeton University Press, Princeton, 2010.
5. Ranier. W, Nano Electronics and Information Technology, Wiley, 2013.

COURSE OUTCOMES:

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

CO1: the Maxwell equation for Photonic systems and other basics of nanophotonics

CO2: the mechanism of scanning optical microscopy and advanced lithography techniques

CO3: the surface plasmon resonance (SPR) effect and its applications towards optical waveguides

CO4: the working mechanism of optoelectronics devices Quantum wire lasers and hite LEDs

CO5: the applications of Plamonics

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CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHEY 307	OPTICAL COMPUTING	L	T	P	C
SDG: 4		3	1	0	3

COURSE OBJECTIVES:

- **COB1:** To introduce the concepts of digital images and optical computation.
- **COB2:** To understand the analog based optical computing
- **COB3:** To provide knowledge of advanced digital communications areas
- **COB4:** To introduce the students to ideas concerning optical neural networks
- **COB5:** To gain knowledge on advanced memory techniques such as associative memory and artificial intelligence.

MODULE I DIGITAL IMAGE PROCESSING FUNDAMENTALS **9**

Digital Image fundamentals - sampling and Quantization - Image Enhancement – Image Restoration – image filtering

MODULE II ANALOG OPTICAL COMPUTING **9**

Optical Computing 4f - fourier system - Spatial filtering - Inverse filtering – Deblurring - Analog Optical Arithmetic - Halftone processing - Non-linear Optical processing - Matched filter - Joint transform correlation - Phase only filter - Amplitude-modulated recognition filters - Generalized correlation filter.

MODULE III DIGITAL LOGIC **9**

Number Systems - Number representations - Codes - Arithmetic Operations - Logic elements and Operations - Basic Logic Operations - Logic function formulations - Boolean Algebra - Minimization of function using K-map - Universal Logic gates - Logic functions using Multiplexers - Threshold Logic - Combinational Logic- Binary Adders - Carry-Look Ahead adder - Arithmetic Logic Unit- Decoders and encoders - Sequential Logic -Flip-flops- Synchronous sequential circuits – Counters

MODULE IV DIGITAL OPTICAL COMPUTING **9**

Non-linear devices - Integrated Optics - Threshold Devices - Spatial Light Modulators -

Theta Modulation Devices - Shadow casting and Symbolic substitution - Design Algorithm - POSC Logic operations - POSC Multiprocessor Parallel and Sequential ALU using POSC - POSC Image Processing - Symbolic Substitution- Optical Implementation- Limitations and Challenges - Optical Matrix Processing Multiplication using Convolution - Matrix Operations - Cellular Logic Architecture - Programmable Logic Array.

MODULE V OPTICAL NEURAL NETWORKS 9

Neural Networks - Associative Memory - Optical Implementations Interconnections - Artificial Intelligence.

L – 45; TOTAL HOURS –45

REFERENCES:

1. Mohammad A. Karim and Abdul A.S. Awwal, "Optical Computing - An Introduction", John Wiley & Sons, 2003.
2. Alistair D. McAulay, "Optical Computer Architectures", John Wiley & Sons, 1991.
3. Dror G. Fritelson, "Optical Computing", The MIT Press, 1988.
4. B.S. Wherrett and F.A.P. Tooley, "Optical Computing", Heriot-WattUniversity, Edinburgh, 1988..Henri H. Arsenault et al., "Optical Processing and Computing", Academic Press, London, 1989.
5. Morris Mano, "Fundamentals of Digital Logic Circuits", Prentice Hall, 2002.

COURSE OUTCOMES:

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

- **CO1:** explain digital image fundamentals and various imaging techniques
- **CO2:** explore the analog computing process
- **CO3:** gain required exposure to principle & working of digital logic operations
- **CO4:** understand the concept of neural networks
- **CO5:** explain concept related to advanced memory techniques

Board of Studies (BoS) : Mention details of BoS

Academic Council: Mention Number and date

BOS of Physics was held on 30.6.22 15.10.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PS O2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 4 : Ensuring inclusive and equitable quality education for all persons and promote lifelong learning opportunities.

Statement : The modules and topics mentioned in this course are designed to ensure all inclusive and thorough education with equity to all persons and promote learning opportunities at all times.

PHEY 308	THIN FILM SCIENCE AND TECHNOLOGY	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To familiarize with preparation and properties of thin films.

COB2: To understand the different kinetics of thin film nucleation.

COB3: To understand the characterization tools for thin films.

COB4: To study the different properties of thin films.

COB5: To apply the knowledge of thin film technology into applications.

MODULE I PREPARATION OF THIN FILMS 9

Kinetic aspects of gases in a vacuum chamber – classifications of vacuum ranges – production of vacuum - pressure measurement in vacuum systems– thin film (epitaxy) – definition – types of epitaxy. Different Growth Techniques: Liquid phase epitaxy – vapour phase epitaxy – molecular beam epitaxy – metal organic vapour phase epitaxy – sputtering (RF & DC) – pulsed laser deposition. Thickness Measurement: Microbalance technique – photometry-ellipsometry– interferometry.

MODULE II KINETICS OF THIN FILMS 9

Nucleation Kinetics: types of nucleation – kinetic theory of nucleation – energy formation of a nucleus – critical nucleation parameters; spherical and non spherical (cap, disc and cubic shaped) Growth Kinetics: Kinetics of binary (GaAs, InP, etc.), ternary (Al1-xGaxAs, Ga1-xInxP, InAs1-xPx, etc.) and quaternary (Ga1-xInxAs1 - yPy, etc.) semiconductors – derivation of growth rate and composition expressions.

MODULE III CHARACTERIZATION 9

X-ray diffraction – photoluminescence – UV-Vis-IR spectrophotometer – Atomic Force Microscope – Scanning Electron Microscope – Hall effect – Vibrational Sample Magnetometer – Secondary Ion Mass Spectrometry – X-ray Photoemission Spectroscopy.

MODULE IV PROPERTIES OF THIN FILMS 9

Dielectric properties – experimental technique for the determination of dielectric properties – optical properties – experimental technique for the determination of optical constants – mechanical properties – experimental technique for the determination of mechanical properties of thin films – magnetic and superconducting properties.

MODULE V APPLICATIONS 9

Optoelectronic devices: LED and Solar cell – Micro Electromechanical Systems (MEMS) – Fabrication of thin film capacitor – application of ferromagnetic thin films; data storage, Giant Magnetoresistance (GMR) – sensors – fabrication and characterization of thin film transistor and FET – quantum dot - Cryptography.

L – 45; TOTAL HOURS –45

REFERENCES:

1. Goswami. A, Thin Film Fundamentals, New Age International (P) Limited, New Delhi, 1996.
2. AichaEishabini-Riad, Fred D. Barlow and ISHN, Thin film Technology Handbook, McGraw-Hill Professional Publishers, 1997.
3. Krishna Seshan, Handbook of Thin Film Deposition, William Andrew Publishers, 2012.
4. Donald Smith, Thin-Film Deposition: Principles and Practice, McGraw-Hill Professional Publishers, 1995.
5. K.L.Chopra, “Thin Film Phenomena”, Malabar: Robert E. Krieger Publishing Company, 1979.

COURSE OUTCOMES:

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

CO1: the basic concepts about the thin film technology

CO2: the different kinetics of thin film nucleation.

CO3: the characterization tools for thin films.

CO4: Structural, optical, dielectric and mechanical properties of thin films

CO5: applications of thin films in optoelectronics

Board of Studies (BoS) :

BOS of Physics was held on 30.6.22

Academic Council:

19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PS O2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 4 : Ensuring inclusive and equitable quality education for all persons and promote lifelong learning opportunities.

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PHEY 309	CORROSION SCIENCE AND TECHNOLOGY	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To enable the students understand principles behind corrosion science.

COB2: To expose the students to various instrumental techniques.

COB3: To familiarize the students with methods of coating

COB4: To help the students in the corrosion in selected environments

COB5: To make the students to understand various corrosion processes and engineering applications.

MODULE I CORROSION PROCESSES 9

Basic principles of electrochemistry and aqueous corrosion processes - Electrochemical Thermodynamics and Electrode Potential - Electrochemical Kinetics of Corrosion Cathodic and anodic behavior - Faraday's Law - Nernst equation; standard potentials Pourbaix diagram - Tafel equations, corrosion rate - Evans diagram - pitting, crevice and exfoliation corrosion; influence of deposits and anaerobic conditions; corrosion control; high temperature oxidation and hot corrosion; corrosion/mechanical property interactions.

MODULE II ORTHOPAEDIC MATERIALS 9

ray diffraction, TEM, SEM and EDX, WDX analysis, surface analysis by AES, XPS and SIMS, overview of other techniques.

MODULE III CARDIOVASCULAR MATERIALS 9

Electrodeposition; flame and plasma spraying; thermal, HV of detonation gun, gas dynamic spray, physical vapour deposition; chemical vapour deposition; HIP surface treatments devices, probability-internal conversion- nuclear isomerism.

MODULE IV DENTAL MATERIALS 9

Atmospheric Corrosion, Corrosion in Automobiles, Corrosion in Soils, Corrosion of Steel in Concrete, Corrosion in Water, Microbiologically Induced Corrosion, Corrosion in the Body, Corrosion in the Petroleum Industry, Corrosion in the Aircraft Industry, Corrosion in the Microelectronics Industry

MODULE V MATERIALS IN OPTHALMOLOGY 9

Abrasive, erosive and sliding wear. The interaction between wear and corrosion. Coating systems for corrosion and wear protection; new coating concepts including multi-layer structures, functionally gradient materials, intermetallic barrier coatings and thermal barrier coatings.

L – 45; TOTAL HOURS –45

REFERENCES:

1. D.A. Jones, Principles and Prevention of Corrosion, 2nd Edition, Macmillan Publishing Co., 1995.
2. J.O.M. Bockris, B.E. Conway, E. Yeager and White, Electrochemical Materials Science in Comprehensive Treatise of Electrochemistry, Volume 4, Plenum press, 2001.
3. M.G. Fontanna and N.D. Greene, Corrosion Engineering, McGraw-Hill publishing, 1978
4. I.M. Hutchings, Tribology: Friction and Wear of Engineering Materials, CRC press, Boca Raton, 1992 D.O. Sprowds, Corrosion Testing and Evaluation, Corrosion Metals Hand book, vol. 13, 1986.

COURSE OUTCOMES:

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

CO1: various corrosion process involved in electrochemistry

CO2: working mechanism of various instrumentation techniques

CO3: various coating process,

CO4: applications of coatings towards environmental safety

CO5: industrial applications of coatings

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PS O2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHEY 310	BIOMATERIALS	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To enable the students understand importance of and properties of Biomaterials

COB2: To familiarize the students with different orthopaedic materials.

COB3: To understand different cardiovascular materials.

COB4: To help students study about materials in opthalmology

COB5: To make the students understand applications of various biomaterials

MODULE I BIOLOGICAL PERFORMANCE OF MATERIALS **9**

Biocompatibility- Introduction to the biological environment – Material response: swelling and leaching, corrosion and dissolution, deformation and failure, friction and wear – Host response: the inflammatory process - coagulation and hemolysis- approaches to thrombo- resistant materials development.

MODULE II ORTHOPAEDIC MATERIALS **9**

Bone composition and properties - temporary fixation devices - joint replacement – Biomaterials used in bone and joint replacement: metals and alloys – Stainless steel, cobalt based alloys, titanium based materials – Ceramics: carbon, alumina, zirconia, bioactive calcium phosphates, bioglass and glass ceramics – polymers: PMMA, UHMWPE/HDPE, PTFE – Bone cement – Composites.

MODULE III CARDIOVASCULAR MATERIALS **9**

Blood clotting – Blood rheology – Blood vessels – The heart – Aorta and valves – Geometry of blood circulation – The lungs - Vascular implants: vascular graft, cardiac valve prostheses, cardiac pacemakers – Blood substitutes – Extracorporeal blood circulation devices.

probability-internal conversion- nuclear isomerism.

MODULE IV DENTAL MATERIALS **9**

Teeth composition and mechanical properties – Impression materials – Bases, liners and varnishes for cavities – Fillings and restoration materials – Materials for oral and maxillofacial surgery – Dental cements and dental amalgams – Dental adhesives.

MODULE V MATERIALS IN OPTHALMOLOGY 9

Biomaterials in ophthalmology – Viscoelastic solutions, contact lenses, intraocular lens materials – Tissue grafts – Skin grafts – Connective tissue grafts – Suture materials – Tissue adhesives – Drug delivery: methods and materials – Selection, performance and adhesion of polymeric encapsulants for implantable sensors-biomemtic materials-Technology from nature.

L – 45; TOTAL HOURS –45

REFERENCES:

1. Sujata V. Bhat. Biomaterials, Narosa Publication House, New Delhi, 2002.
2. Jonathn Black. Biological Performance of Materials: Fundamentals of biocompatibility, Marcel Dekker Inc, New York, 1992.
3. D.F.Williams (editor). Materials Science and Technology: A comprehensive treatment, Volume 14. Medical and Dental Materials, VCH Publishers Inc, New York, 1992.
4. F.Silver and C.Doillon. Biocompatibility: Interactions of Biological and implantable materials. Volume I Polymers, VCH Publishers Inc, New York, 1989.
5. L.L.Hench and E.C.Ethridge. Biomaterials: An Interfacial Approach, Academic Press, 1982.
6. Joon Park, R. S. Lakes, Biomaterials. An Introduction, Springer, third edition, 2010. Springer

COURSE OUTCOMES:

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

CO1: importance and properties of biomaterial..

CO2: different classes of orthopaedic materials

CO3: different types of cardiovascular materials.

CO4: various types of materials used in ophthalmology.

CO5: applications of various biomaterials

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PS O2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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PHEY 311	ADVANCED MATERIALS FOR ENERGY APPLICATIONS	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To understand the fundamentals and basics of materials for solar energy.

COB2: To provide the knowledge of the synthesis of materials.

COB3: To understand about the characterization of materials.

COB4: To provide an understanding of energy harvesting materials.

COB5: To provide insights in to the energy storage materials.

MODULE I MATERIALS FOR PHOTOVOLTAICS 9

First generation solar cell materials; single and polycrystalline Silicon, amorphous silicon: growth and wafer processing, contact materials, materials for surface engineering. Second generation solar cell materials; CdSe, CdTe, Copper Indium Gallium Selenide (CIGS), Gallium Arsenide for applications in photovoltaics, Materials for thin film solar cells, Thin film processing, and properties. Contact materials for second generation solar cells. Third generation solar cell materials; Quantum Dots, Organic materials, Composites, Dyes, Perovskites and their synthesis, characterization and properties, Interface energetics, photoactive layers and their materials, role of electron transport, hole transport, electron blocking and hole blocking materials and their processing. Contact materials and processing of contact layers.

MODULE II RECHARGEABLE BATTERIES 9

Primary and secondary batteries, battery potential, charge figure of merit, energy and power in battery, polarization losses, thermodynamics of battery materials, tortuosity and porosity of battery materials, reversible and irreversible interfacial reactions, battery architecture and design guidelines, Lead–acid battery, Nickel–cadmium battery (NiCd), Nickel–metal hydride battery (NiMH), Lithium-ion battery, Lithium-ion polymer battery, Energy density, power density, price and market. Battery Management systems and System Performance

MODULE III SUPERCAPACITORS AND HYDROGEN STORAGE **9**

Basic components of supercapacitors like types of electrodes like high surface area activated carbons, metal oxide and conducting polymers, aqueous and organic electrolytes

Background and working of Fuel Cell, Hydrogen production processes, Hydrogen storage: Physical and chemical properties, general storage methods, compressed storage-composite cylinders, glass micro sphere storage, zeolites, metal hydride storage, chemical hydride storage and cryogenic storage, Carbon based materials for hydrogen storage.

MODULE IV MATERIALS FOR ENERGY HARVESTING **9**

Piezoelectric, Pyroelectric and Thermo-electrics materials, Electrostatic (capacitive) Energy Harvesting and materials, energy from Magnetic Induction, Metamaterial, energy from atmospheric pressure changes, electroactive polymers (EAPs), nanogenerators, Ambient radiation sources and nanoantenna, energy from noise.

MODULE V MATERIALS FOR ENERGY STORAGE **9**

Electrochemistry and electro-chemical Battery materials, Hydrogen Storage materials for fuel cells: Metal hybrids, Nanostructured metal hydrides, Non-metal hydrides, Carbohydrates, Synthesis of hydrocarbons, Aluminum, Liquid organic hydrogen carriers (LOHC), Ammonia, Amine borane complexes, Nano borohydrides and nano catalyst doping, imidazolium ionic liquids, phosphonium borate, Carbonite substances, Metal Organic frameworks, Activated Carbons, Carbon nanotubes, Clathrate hydrates, Glass capillary arrays.

L – 45; TOTAL HOURS –45

REFERENCES:

1. Detlef Stolten,“Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications”, Wiley, 2010.
2. Jiujun Zhang, Lei Zhang, Hansan Liu, Andy Sun, Ru-Shi L iu, “Electrochemical Technologies for Energy Storage and conversion”, John Wiley and Sons, 2012.

3. Francois Beguin and Elzbieta Frackowiak ,“Super capacitors”, Wiley, 2013.
4. Doughty Liaw, Narayan and Srinivasan, “Batteries for Renewable Energy Storage”, The Electrochemical Society, New Jersy,2010.

COURSE OUTCOMES:

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

CO1: analyze the different energy storage systems.

CO2: understand the concepts and design of batteries

CO3: get the insights into supercapacitors and hydrogen fuels

CO4: comprehend the ideas behind the materials used for energy harvesting.

CO5:get familiarized with the different materials used for energy applications.

Board of Studies (BoS) : BOS of Physics was held on 30.6.22

Academic Council: 19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 4 : Ensuring inclusive and equitable quality education for all persons and promote lifelong learning opportunities.

Statement : The modules and topics mentioned in this course are designed to ensure all inclusive and thorough education with equity to all persons and promote learning opportunities at all times.

OPEN ELECTIVE COURSES

OEEY 731	**ADVANCED MATERIALS FOR**	**L**	**T**	**P**	**C**
SDG: 4	**ENERGY APPLICATIONS**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

COB1: To understand the fundamentals and basics of materials for solar energy.

COB2: To provide the knowledge of the synthesis of materials.

COB3: To understand about the characterization of materials.

COB4: To provide an understanding of energy harvesting materials.

COB5: To provide insights in to the energy storage materials.

MODULE I MATERIALS FOR PHOTOVOLTAICS 9

First generation solar cell materials; single and polycrystalline Silicon, amorphous silicon: growth and wafer processing, contact materials, materials for surface engineering. Second generation solar cell materials; CdSe, CdTe, Copper Indium Gallium Selenide (CIGS), Gallium Arsenide for applications in photovoltaics, Materials for thin film solar cells, Thin film processing, and properties. Contact materials for second generation solar cells. Third generation solar cell materials; Quantum Dots, Organic materials, Composites, Dyes, Perovskites and their synthesis, characterization and properties, Interface energetics, photoactive layers and their materials, role of electron transport, hole transport, electron blocking and hole blocking materials and their processing. Contact materials and processing of contact layers.

MODULE II RECHARGEABLE BATTERIES 9

Primary and secondary batteries, battery potential, charge figure of merit, energy and power in battery, polarization losses, thermodynamics of battery materials, tortuosity and porosity of battery materials, reversible and irreversible interfacial reactions, battery architecture and design guidelines, Lead–acid battery, Nickel–cadmium battery (NiCd), Nickel–metal hydride battery (NiMH), Lithium-ion battery, Lithium-ion polymer battery, Energy density, power density, price and market. Battery Management systems and System Performance

MODULE III SUPERCAPACITORS AND HYDROGEN STORAGE **9**

Basic components of super capacitors like types of electrodes like high surface area activated carbons, metal oxide and conducting polymers, aqueous and organic electrolytes Background and working of Fuel Cell, Hydrogen production processes, Hydrogen storage: Physical and chemical properties, general storage methods, compressed storage-composite cylinders, glass micro sphere storage, zeolites, metal hydride storage, chemical hydride storage and cryogenic storage, Carbon based materials for hydrogen storage.

MODULE IV MATERIALS FOR ENERGY HARVESTING **9**

Piezoelectric, Pyroelectric and Thermo-electrics materials, Electrostatic (capacitive) Energy Harvesting and materials, energy from Magnetic Induction, Metamaterial, energy from atmospheric pressure changes, electroactive polymers (EAPs), nanogenerators, Ambient radiation sources and nanoantenna, energy from noise.

MODULE V MATERIALS FOR ENERGY STORAGE **9**

Electrochemistry and electro-chemical Battery materials, Hydrogen Storage materials for fuel cells: Metal hybrids, Nanostructured metal hydrides, Non-metal hydrides, Carbohydrates, Synthesis of hydrocarbons, Aluminum, Liquid organic hydrogen carriers (LOHC), Ammonia, Amine borane complexes, Nano borohydrides and nano catalyst doping, imidazolium ionic liquids, phosphonium borate, Carbonite substances, Metal Organic frameworks, Activated Carbons, Carbon nanotubes, Clathrate hydrates, Glass capillary arrays.

L – 45; TOTAL HOURS –45

REFERENCES:

1. Detlef Stolten,“Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications”, Wiley, 2010.
2. Jiujun Zhang, Lei Zhang, Hansan Liu, Andy Sun, Ru-Shi Liu,

3. "Electrochemical Technologies for Energy Storage and conversion", John Wiley and Sons, 2012.
4. Francois Beguin and Elzbieta Frackowiak ,"Super capacitors", Wiley, 2013.
5. Doughty Liaw, Narayan and Srinivasan, "Batteries for Renewable Energy Storage", The Electrochemical Society, New Jersy,2010.

COURSE OUTCOMES:

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

CO1: analyze the different energy storage systems.

CO2: understand the concepts and design of batteries

CO3: get the insights into supercapacitors and hydrogen fuels

CO4: comprehend the ideas behind the materials used for energy harvesting.

CO5:get familiarized with the different materials used for energy applications.

Board of Studies (BoS) : BOS of Physics was held on 30.6.22

Academic Council: 19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PS O2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

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OEEY 732	ALTERNATIVE ENERGY	L	T	P	C
SDG: 7,9	RESOURCES	3	0	0	3

COURSE OBJECTIVES:

The students will be trained about the

COB1: Different types of batteries

COB2: Factors affecting battery performance

COB3: Selection and application of batteries

COB4: Application in photovoltaic cells

COB5: Various materials used in solar cells and PEC cells

MODULE I BATTERIES 9

Lithium-ion battery, The Principle carbonaceous anode materials, cathode material- The intercalative reactions, relationships between performance requirements and materials characteristics- Electrolyte, separator. Advanced Ni-MH Batteries: Improvement in hydrogen storage alloys, improvement in Cathode materials, improvement in separator and cell design.

MODULE II FACTORS AFFECTING BATTERY PERFORMANCE AND SELECTION OF BATTERIES 9

Factors affecting battery capacity, voltage level current drain of discharge, types of discharge continuous, intermittent, constant current, constant load, constant power, temperature of battery during discharge, service life, voltage regulation, changing voltage, effect of all design, battery age and storage condition, effect of battery design. Major consideration in selecting a battery, battery applications, comparative features and performance characteristics, characteristics of batteries for portable equipment.

MODULE III PHOTOVOLTAICS 9

Basic of photovoltaics, homo and heterojunctions, preparation of single crystals and polycrystalline silicon solar cells, Metal-Insulator-Metal and semiconductors - Insulator-semiconductors solar cells, photovoltaic measurements - I-V characteristics, spectral response and capacitance measurements.

MODULE IV FUEL CELLS AND SUPER CAPACITORS 9

Introduction, Types of Fuel cells, figure of merit, electro catalysts for hydrogen oxidation and oxygen reduction, electrochemical double layer capacitors, ruthenium oxide as capacitor electrode, manual capacitors with proton conducting solid polymer electrolytes.

Ultra capacitors: Double layer, Metal Oxide, conducting polymers energy and power densities, voltage limitation and self discharge.

MODULE V SOLAR CELLS AND PEC CELLS 9

Preparation of CdS/Cu_2S solar cells by screen printing technique and their characteristics, amorphous Si solar cells GaAs solar cells, Semiconductors electrolyte interface. Photoelectrochemical (PEC) cells for conversion of light energy to electrical energy, PEC cells based on CdSe Si and GaAs and their output characteristics, Estimation of flat band potential from Mott-Schottky plots.

L – 45; TOTAL HOURS – 45

REFERENCES:

1. Energy Storage Systems for Electronics Edited by Tetsuya Osaka, Department of Applied Chemistry, Wasuda University, Tokyo, Japan and Madhav Dutta, Intel Corporation, Hillsboro, USA, 2000.
2. Photoelectrochemical Solar Cell, Edited By K.S.V. Santhanam and M. Sharon, Elsevier Science Publishers, BV New York, 1995.
3. A.F. Fahrenbruch and R.H. Bube, Fundamentals of Solar Cells, Academic Press, London 1983.
4. W.E. Hatified and J.H. Miller (Editors), High Temperature Superconducting Materials, Marcel Dekker, New York 1988.
5. Lindar D., Handbook on Batteries and Fuel Cells, McGraw Book Co., New York, 2011.

COURSE OUTCOMES:

The students will have

CO1: A thorough understanding about batteries and their components

CO2: Understand the working mechanism of batteries.

CO3: Influence of various factors on performance of batteries and based on which selection of suitable batteries depending on application.

CO4: Testing in fuel cells.

CO5: Applications in solar cells and PEC cells.

Board of Studies (BoS):
12th BoS of Chemistry held on 22.07.2022

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1		M			H										
CO2	H			H	M										
CO3		H				L									
CO4	M			H		L									
CO5	H				M										

Note: L- Low Correlation M - Medium Correlation H -High Correlation

SDG 7: Affordable & Clean Energy
SDG 9 : Industry, Innovation and Infrastructure

Statement:
SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all
SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

OEEY 701	ANALYTICAL TECHNIQUES	L	T	P	C
SDG: 6, 7		3	0	0	3

COURSE OBJECTIVES:

To make the students to understand the

COB1: basics in data analysis

COB2: basics and principles in volumetric and gravimetric analysis

COB3: types and principles of electro analytical methods

COB4: principles and analysis of spectroscopic techniques

COB5: the principle and methods in chromatography and thermal analysis

MODULE I DATA ANALYSIS 9

Precision and accuracy, Classification of errors, methods of minimization and elimination of errors Mean and standard deviation; absolute and relative errors; students t-test, F-test, linear regression for deriving calibration plots, covariance and correlation coefficient

Statistics for analytical experimentation: Probability, Regression analysis, Data analysis and signal enhancement.

MODULE II VOLUMETRIC METHODS OF ANALYSIS 9

Different methods of expressing concentration terms, Difference between titrimetic and volumetric analysis, Types and roles of indicators - Principle and reactions involved in neutralization, precipitation, complexometric and redox titrations, calculations involving stoichiometry – for all types of systems - Gravimetric analysis (volatilisation and precipitation methods)

MODULE III ELECTROANALYTICAL METHODS 9

Types of electrodes - Conductometric Titrations - Potentiometric titrations - pH-metry and ion-selective electrodes - Amperometric titrations - Coulometric Titrations, DM Electrode - polarography - electrogravimetry - voltammetry, cyclic voltammetry, impedance studies - Electrochemical sensors, ISFETs, CHEMFETs.

MODULE IV SPECTROPHOTOMETRIC TECHNIQUES 9

Quantitative applications of Colorimetric analysis – UV-Visible spectrophotometry – *Atomic absorption spectroscopy* (*AAS*) - atomic emission spectroscopy (AES), *Flame photometry*, ICP-AES - Fluorescence spectroscopy, Stern Volmer Equation and quantum yield calculation.

MODULE V CHROMATOGRAPHIC TECHNIQUES AND THERMAL METHODS 9

Chromatography**:** Paper, TLC and column Chromatography – Detectors in Chromatography - GC, HPLC, (hyphenated techniques GC/MS, LC/MS) and GPC -– ion exchange chromatography – Electrochromatography**:** Capillary electrophoresis and gel electrophoresis

Thermal analytical techniques: TGA, DTA, DSC, DMA – Chemisorption Techniques – TPD, TPO, TPR, TPS.

L – 45 ; TOTAL HOURS – 45

TEXT BOOKS:

1. Skoog D.A., West D.M., Holler F.J. and Crouch S.R., Fundamentals of Analytical Chemistry, 8th Edition, Thomson Brooks/Cole Publication., Singapore, 2004.
2. Willard H.H., Merritt L.L., Dean J.A. and Settle F.A., Instrumental Methods of Analysis, 7th Edition, CBS Publication, New Delhi Reprint, 2004.
3. Skoog D.A., Holler F.J. and Nieman T.A., Principles of Instrumental Analysis, 5th Edition, Harcourt College Publication., Singapore, 1998.
4. Christian G.D., Analytical Chemistry, 6th Edition, John Wiley, Singapore, 2003.
5. Fifield F.W. and Kealey D., Principles and Practice of Analytical Chemistry, 5th Edition, Blackwell Publication, London, 2000.
6. Settle F. (Editor), Handbook of Instrumental Techniques for Analytical Chemistry, Pearson Education, Singapore, 2004.

COURSE OUTCOMES:

The student will be able to

CO1: analyse the numerical data without error
CO2: perform the volumetric and gravimetric analysis of chemical compounds and interpret the result
CO3: perform the electro analytical titrations and analyse the result
CO4: identify the appropriate spectral technique and do the spectral analysis and interpret the data
CO5: perform the chromatographic techniques and separate the compounds

Board of Studies (BoS):
12th BoS of Chemistry held on 22.07.2022

Academic Council:
19th AC held on 29.09.2022

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	M	M		M											
CO 2	H	M		M											
CO 3	H	M		M		H									
CO 4	H	M		M	M	H									
CO 5	H	M		M	M	H									

Note: L- Low Correlation M - Medium Correlation H -High Correlation

SDG 6: Clean Water & Sanitation
SDG 7: Affordable and Clean Energy

Statement: Through various analytical methods, innovative, cheap and affordable materials can be developed and can be employed in the area of clean water, sanitation and energy

OEEY 733	BIOMASS FOR ENERGY	L	T	P	C
SDG: 7	APPLICATIONS	3	0	0	3

COURSE OBJECTIVES:

To make the student conversant with

COB1: Structure, properties and applications of cellulose, hemicelluloses and lignin.

COB2: Types of biomass used as feedstock for energy applications

COB3: Various biomass pretreatment techniques.

COB4: Understand the chemistry and economics of biodiesel

COB5: Understand the conversion of lignocelluloses into alcohol and fuel.

MODULE I STRUCTURE AND PROPERTIES OF BIOMASS 9

Chemistry of polysaccharides, Structure and properties of cellulose, Addition and substitution reactions, Structure and properties of hemicelluloses, Hydrolysis of cellulose by acid and enzyme, Chemistry of lignin, Biosynthesis of lignin, Structure and properties of lignin, Isolation and application of lignin, Chemistry of extractives.

MODULE II BIOMASS FEEDSTOCKS 9

Availability and abundance, photosynthesis, composition and energy potential, virgin biomass production and selection, waste biomass (municipal, industrial, agricultural and forestry) availability, abundance and potential, biomass as energy resources: dedicated energy crops, annual crops (maize, sorghum sugar beet, hemp), perennial herbaceous crops (sugarcane, switchgrass, miscanthus), short rotation woody crops (poplar, willow), oil crops and their biorefinery potential, microalgae as feedstock for biofuels and biochemical, enhancing biomass properties for biofuels, challenges in conversion.

MODULE III BIOMASS PRETREATMENT 9

Biomass pretreatment-Physical pretreatment methods – milling, microwave, mechanical extrusion, pulse electric field; Chemical pretreatment methods - acid pretreatment, alkali pretreatment, Organosolv pretreatment, Ionic liquids pretreatment; Physico-chemical pretreatment - Steam explosion pretreatment, Ammonia fiber explosion (AFEX) pretreatment; CO_2 explosion, wet oxidation, sulphite pretreatment; Biological pretreatment

MODULE IV BIODIESEL 9

Chemistry and Production Processes; Vegetable oils and chemically processed biofuels; Biodiesel composition and production processes; Biodiesel economics; standards for biodiesel quality; Energetics of biodiesel production and effects on greenhouse gas emissions Issues of ecotoxicity and sustainability with ; expanding biodiesel production

MODULE V BIOETHANOL 9

Biochemical conversion of lignocellulose to alcohol, Separate hydrolysis and fermentation process (SHF), Simultaneous saccharification and fermentation process (SSF), Consolidated Bioprocess (CBP), Pentose fermentation by yeast and bacteria. **Thermochemical conversion of biomass to liquid fuels**, Combustion, Pyrolysis process of lignocellulose to liquid fuels, Gasification process, Cogeneration and polygeneration. Innovative cycles (such as biomass integrated gasification combined cycles, biomass air turbines, humid air turbines etc) for biomass resources, Bioethanol production.

L – 45; Total Hours –45

REFERENCES:

1. Krzysztof J Ptasinski, Efficiency of Biomass Energy: An Exergy Approach to Biofuels, Power, and Biorefineries, John Wiley and Sons, 2015.
2. Kaltschmitt, Martin, Energy from Organic Materials (Biomass), A Volume in the Encyclopedia of Sustainability Science and Technology, Second Edition, 2019.
3. George W. Huber, Sara Iborra, AvelinoCorma, Synthesis of Transportation Fuels from Biomass: Chemistry, Catalysts, and Engineering, Chemical Review 2006, 106, 9, 4044-4098.

COURSE OUTCOMES:

Students will be able to

CO1: Identify the structure and properties of cellulose, hemicelluloses and lignin.

CO2: Find the significance of different biomass resources.

CO3: Illustrate biomass pretreatment techniques.

CO4: Synthesize the biodiesel at economical price.
CO5: Produce the bioethanol at economical price.

Board of Studies (BoS):
12th BoS of Chemistry held on 22.07.2022

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	H	M	M	M	H									
CO2	M	H	M	M	M	H									
CO3	M	H	M	M	M	H									
CO4	M	H	M	M	M	H									
CO5	M	H	M	M	M	H									

Note: L - Low Correlation M - Medium Correlation H - High Correlation

SDG 7: Affordable & Clean Energy: Ensure access to affordable, reliable, sustainable and modern energy for all.

Statement: Utilization of biomass for the energy need provide solution for affordable and sustainable energy for all.

OEEY 703	BIOMATERIALS	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To enable the students understand importance of and properties of Biomaterials

COB2: To familiarize the students with different orthopaedic materials.

COB3: To understand different cardiovascular materials.

COB4: To help students study about materials in opthalmology

COB5: To make the students understand applications of various biomaterials

MODULE I BIOLOGICAL PERFORMANCE OF MATERIALS 9

Biocompatibility- Introduction to the biological environment – Material response: swelling and leaching, corrosion and dissolution, deformation and failure, friction and wear – Host response: the inflammatory process - coagulation and hemolysis- approaches to thrombo- resistant materials development.

MODULE II ORTHOPAEDIC MATERIALS 9

Bone composition and properties - temporary fixation devices - joint replacement – Biomaterials used in bone and joint replacement: metals and alloys – Stainless steel, cobalt based alloys, titanium based materials – Ceramics: carbon, alumina, zirconia, bioactive calcium phosphates, bioglass and glass ceramics – polymers: PMMA, UHMWPE/HDPE, PTFE – Bone cement – Composites.

MODULE III CARDIOVASCULAR MATERIALS 9

Blood clotting – Blood rheology – Blood vessels – The heart – Aorta and valves – Geometry of blood circulation – The lungs - Vascular implants: vascular graft, cardiac valve prostheses, cardiac pacemakers – Blood substitutes – Extracorporeal blood circulation devices.

probability-internal conversion- nuclear isomerism.

MODULE IV DENTAL MATERIALS 9

Teeth composition and mechanical properties – Impression materials – Bases, liners and varnishes for cavities – Fillings and restoration materials – Materials

for oral and maxillofacial surgery – Dental cements and dental amalgams – Dental adhesives.

MODULE V MATERIALS IN OPTHALMOLOGY 9

Biomaterials in ophthalmology – Viscoelastic solutions, contact lenses, intraocular lens materials – Tissue grafts – Skin grafts – Connective tissue grafts – Suture materials – Tissue adhesives – Drug delivery: methods and materials – Selection, performance and adhesion of polymeric encapsulants for implantable sensors- biomemtic materials-Technology from nature.

L – 45; TOTAL HOURS –45

REFERENCES:

1. Sujata V. Bhat. Biomaterials, Narosa Publication House, New Delhi, 2002.
2. Jonathn Black. Biological Performance of Materials: Fundamentals of biocompatibility, Marcel Dekker Inc, New York, 1992.
3. D.F.Williams (editor). Materials Science and Technology: A comprehensive treatment, Volume 14. Medical and Dental Materials, VCH Publishers Inc, New York, 1992.
4. F.Silver and C.Doillon. Biocompatibility: Interactions of Biological and implantable materials. Volume I Polymers, VCH Publishers Inc, New York, 1989.
5. L.L.Hench and E.C.Ethridge. Biomaterials: An Interfacial Approach, Academic Press, 1982.
6. Joon Park, R. S. Lakes, Biomaterials. An Introduction, Springer, third edition, 2010. Springer

COURSE OUTCOMES:

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

CO1: importance and properties of biomaterial..

CO2: different classes of orthopaedic materials

CO3: different types of cardiovascular materials.

CO4: various types of materials used in ophthalmology.

CO5: applications of various biomaterials

Board of Studies (BoS) : **Academic Council:**

19th AC held on 29.09.2022

BOS of Physics was held on
30.6.22

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 4 : Ensuring inclusive and equitable quality education for all persons and promote lifelong learning opportunities.

Statement : The modules and topics mentioned in this course are designed to ensure all inclusive and thorough education with equity to all persons and promote learning opportunities at all times.

OEEY 704	BIOMEDICAL INSTRUMENTATION	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To understand the human physiological systems.

COB2: To know the different aspects of biosignal acquisition.

COB3: To understand the basics in biopotential recorders.

COB4: To know the importance methods, instruments available for biomedical field.

COB5: To analyze the special biomedical instrumentation systems.

MODULE I HUMAN PHYSIOLOGICAL SYSTEMS 9

Cells and their structure – Nature of Cancer cells – Transport of ions through the cell membrane – Resting and action potentials – Bio-electric potentials – Nerve tissues and organs – Different systems of human body. Biopotential Electrodes and Transducers Design of Medical instruments – components of the biomedical instrument system – Electrodes – Transducers.

MODULE II BIOSIGNAL ACQUISITION 9

Physiological signal amplifiers – Isolation amplifiers – Medical preamplifier design – Bridge amplifiers – Line driving amplifier – Current amplifier – Chopper amplifier – Biosignal analysis – Signal recovery and data acquisition – Drift Compensation in operational amplifier – Pattern recognition – Physiological Assist Devices. Pacemakers – Pacemakers batteries – Artificial heart valves – Defibrillators – nerve and muscle stimulators Heart – Lung machine – Kidney machine.

MODULE III BIOPOTENTIAL RECORDERS 9

Characteristics of the recording system – Electrocardiography (ECG) – Electroencephalography (EEG) – Electromyography (EMG) – Electroethinogrphy (ERG) and Electroculography (EOG) – Recorders with high accuracy – recorders for OFF line analysis.

MODULE IV OPERATION THEATRE EQUIPMENT 9

urgical diathermy- shortwave diathermy – Microwave diathermy – Ultrasonic disathermy – Therapeutic effect of heat – Range and area of irritation of different

techniques – Ventilators – Anesthesia machine – Blood flowmeter – Cardiac Output measurements – Pulmonary function analyzers – Gas analyzers – Blood gas analyzers – Oximeters – Elements of intensive care monitoring.

MODULE V SPECIALISED MEDICAL EQUIPMENTS 9

Blood Cell counter – Electron microscope – Radiation detectors – Photometers and colorimeters – digital thermometer – audiometers – X-rays tube – X-ray machine – image intensifiers – Angiography – Application of X-ray examination. Safety instrumentation: Radiation safety instrumentation – Physiological effects due to 50Hz current passage – Microshock and macroshock – electrical accident Hospitals – Devices to protect against electrical hazards – Hospitals architecture.

L – 45; TOTAL HOURS –45

REFERENCES:

1. Arumugam M., Biomedical Instrumentation, Anurada Agencies Publishers, 1992.
2. Khandpur R.S., Handbook of Biomedical Instrumentation, Third Edition, Tata McGraw-Hill Education, 2014.
3. Shakti Chatterjee and Aubert Miller, Biomedical Instrumentation Systems, Cengage Learning Publisher, 2010.
4. Gromwell L., Fred J. Weibell, Erich A. Pfeiffer, Biomedical Instrumentation and Measurements, Second Edition, Prentice Hall, 1980.

COURSE OUTCOMES:

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

CO1: the human physiological systems.

CO2: the different aspects of biosignal acquisition.

CO3: different biopotential recorders such as EEG, ECG, EMG, EOG

CO4: biomedical instruments involved in advanced operation theatres

CO5: the application of biomaterials towards specialized medical equipment such as electron microscope and radiation detectors

Board of Studies (BoS) : **Academic Council:**

BOS of Physics was held on 30.6.22

19th AC held on
29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 4 : Ensuring inclusive and equitable quality education for all persons and promote lifelong learning opportunities.

Statement : The modules and topics mentioned in this course are designed to ensure all inclusive and thorough education with equity to all persons and promote learning opportunities at all times.

OEEY 705	BIOPHOTONICS	L	T	P	C
SDG: 4		3	0	0	3

COURSE OBJECTIVES:

COB1: To know the role of light and its interaction in the cells and tissues.

COB2: To understand the different imaging techniques for the biological systems.

COB3: To know the concepts of spectroscopy in biological applications.

COB4: To understand the optical force spectroscopy.

COB5: To understand the role of Biophotonic materials in applications.

MODULE I INTERACTION OF LIGHT WITH BIOLOGICAL SYSTEMS **9**

Interaction of light with cells, tissues, nonlinear optical processes with intense laser beams, photo-induced effects in biological systems.

MODULE II IMAGING TECHNIQUES **9**

Imaging techniques: Light microscopy, wide-field, laser scanning - confocal, multiphoton, fluorescence lifetime imaging, FRET imaging - Frequency-Domain lifetime imaging. Cellular Imaging - Imaging of soft and hard tissues and other biological structures.

MODULE III SINGLE MOLECULE SPECTROSCOPY **9**

Single molecule spectroscopy: UV-VIS spectroscopy of biological systems, single molecule spectra and characteristics – IR and Raman spectroscopy and Surface Enhanced Raman Spectroscopy for single molecule applications.

MODULE IV OPTICAL FORCE SPECTROSCOPY **9**

Optical Force Spectroscopy: Generation optical forces – Optical trapping and manipulation of single molecules and cells in optical confinement - Laser trapping and dissection for biological systems - single molecule biophysics, DNA protein interactions.

MODULE V BIOSENSORS **9**

Biosensors, Principles- DNA based biosensors – Protein based biosensors– materials for biosensor applications- fabrication of biosensors.

L – 45; TOTAL HOURS –45

REFERENCES:

1. Prasad. P.N., Introduction to Biophotonics, John Wiley & Sons, 2003
2. Michael P. Sheetz, Laser Tweezers in Cell Biology (Methods in Cell Biology), Vol.55, Academic Press Publishers, 1997.
3. Ranier .W, Nanoelectronics and Information Technology, Wiley Publishers, 2012.
4. Drexler. K.E., Nanosystems: Molecular Machinery, Manufacturing and Computation, Wiley Publishers, 1992.

COURSE OUTCOMES:

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

CO1: Make clear insights into the applications of light interaction with biological systems.

CO2: Compare different imaging techniques

CO3: Understand and analyse the various spectroscopic techniques used in biological system.

CO4: Effectively grasp the usage of the optical force spectroscopy.

CO5: Get clear ideas and communicate about the importance of use of spectroscopy in design of bio-photonic devices.

Board of Studies (BoS) : BOS of Physics was held on 30.6.22

Academic Council: 19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 4 : Ensuring inclusive and equitable quality education for all persons and promote lifelong learning opportunities.

Statement : The modules and topics mentioned in this course are designed to ensure all inclusive and thorough education with equity to all persons and promote learning opportunities at all times.

OEEY 734	CORROSION AND CORROSION	L	T	P	C
SDG: 9	CONTROL	3	0	0	3

COURSE OBJECTIVES:

To make the student conversant with the:

COB1: Causes and theories of corrosion.

COB2: Different types of corrosion.

COB3: Basic concepts to prevent corrosion and testing of corrosion by variousdiagrams.

COB4: Factors influencing corrosion.

COB5: Control of corrosion using various methods.

MODULE I CORROSION 9

Causes and effects of corrosion — theories of corrosion – Dry corrosion — oxidation — direct atmospheric effect – Hydrogen corrosion, liquid metal corrosion and corrosion by other gases-electrochemical corrosion – hydrogen evolution – presence and absence of oxygen – corrosion by gaseous reduction.

MODULE II FORMS OF CORROSION 9

Eight forms of corrosion- Galvanic bimetallic corrosion – differential aeration corrosion – concentration cell corrosion – erosion corrosion – pitting corrosion – underground soil corrosion – intergranular corrosion – stress corrosion: Types - seasonal cracking of alloys and caustic embrittlement – corrosion fatigue.

MODULE III CORROSION TESTING 9

Rate of corrosion – calculation of ΔG and other related thermodynamic parameters — potential measurement — electrochemical series — redox reactions — EMF measurement and corrosion current – anodic and cathodic behaviour of metals –passivity – testing of virgin metals – alloy – Pourbaix and Evans diagrams.

MODULE IV FACTORS INFLUENCING CORROSION 9

Nature of metal — over voltage — areas of anodic/cathodic — purity of metal —physical state of metals — passive nature of metal — solubility — volatility of corrosion products – corroding

environment – influence of pH – Pourbaix diagrams- ions – formations of cells – polarization of electrodes.

MODULE V CORROSION CONTROL 9

Design – selection of materials – pure metals and alloys – annealing – elimination of galvanic action – cathodic protection – sacrificial anodic protection and impressed current cathodic protection — modification of environment: deaeration and dehumidification – corrosion inhibitors – protective coatings : preparation of surface before applying coatings – Classification: Inorganic coatings- metallic and non-metallic – organic coatings – special paints – varnish, enamel and lacquers.

L – ; TOTAL HOURS –45

TEXT BOOKS:

1. C.G. Munger and Louis D. Vincent, "Corrosion Prevention by Protective Coatings", Third Edition (e-Book), 2014.

REFERENCES:

1. M.G. Fontana and N.G. Green, Corrosion Engineering, McGraw Hill BookCompany, New York, 1984.
2. J.H. Brophy, R.M. Rose and J. Walf, The Structure and Properties ofMaterials, Wiley Inter Science Inc., New York, 1984.
3. B.T. Kelly, Irradiation Diamagneto Solids, Pergamon Press, New York,1992.
4. D.R. Cross, Principles and Applications of Electrochemistry, Chapman andHall, UK, 1988.

COURSE OUTCOMES:

Students will become familiar with the

CO1: basic concepts of corrosion

CO2: Different types of corrosion and their mechanism of corrosion

CO3: Testing and evaluation of corrosion

CO4: Factors which influence the corrosion

CO5: Control of corrosion in real situation.

Board of Studies (BoS): **Academic Council:**

12th BoS of Chemistry held on 22.07.2022

19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1					L										
CO2															
CO3		H						M							
CO4															
CO5										H					

Note: L- Low Correlation M - Medium Correlation H -High Correlation

SDG 9 : Build resilient Infrastructure, promote inclusive and sustainable industrialization and foster innovation.

The holistic understanding of corrosion and its prevention leads to construction of resilient infrastructure and sustainable industrialization.

OEEY 735	**CORROSION SCIENCE AND TECHNOLOGY**	**L**	**T**	**P**	**C**
SDG: 4		**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

COB1: To enable the students understand principles behind corrosion science.

COB2: To expose the students to various instrumental techniques.

COB3: To familiarize the students with methods of coating

COB4: To help the students in the corrosion in selected environments

COB5: To make the students to understand various corrosion processes and engineering applications.

MODULE I CORROSION PROCESSES 9

Basic principles of electrochemistry and aqueous corrosion processes - Electrochemical Thermodynamics and Electrode Potential - Electrochemical Kinetics of Corrosion Cathodic and anodic behavior - Faraday's Law - Nernst equation; standard potentials Pourbaix diagram - Tafel equations, corrosion rate - Evans diagram - pitting, crevice and exfoliation corrosion; influence of deposits and anaerobic conditions; corrosion control; high temperature oxidation and hot corrosion; corrosion/mechanical property interactions.

MODULE II ORTHOPAEDIC MATERIALS 9

ray diffraction, TEM, SEM and EDX, WDX analysis, surface analysis by AES, XPS and SIMS, overview of other techniques.

MODULE III CARDIOVASCULAR MATERIALS 9

Electrodeposition; flame and plasma spraying; thermal, HV of detonation gun, gas dynamic spray, physical vapour deposition; chemical vapour deposition; HIP surface treatments devices, probability-internal conversion- nuclear isomerism.

MODULE IV DENTAL MATERIALS 9

Atmospheric Corrosion, Corrosion in Automobiles, Corrosion in Soils, Corrosion of Steel in Concrete, Corrosion in Water, Microbiologically Induced Corrosion, Corrosion in the Body, Corrosion in the Petroleum Industry, Corrosion in the Aircraft Industry, Corrosion in the Microelectronics Industry

MODULE V MATERIALS IN OPTHALMOLOGY 9

Abrasive, erosive and sliding wear. The interaction between wear and corrosion. Coating systems for corrosion and wear protection; new coating concepts including multi-layer structures, functionally gradient materials, intermetallic barrier coatings and thermal barrier coatings.

L – 45; TOTAL HOURS –45

REFERENCES:

5. D.A. Jones, Principles and Prevention of Corrosion, 2nd Edition, Macmillan Publishing Co., 1995.
6. J.O.M. Bockris, B.E. Conway, E. Yeager and White, Electrochemical Materials Science in Comprehensive Treatise of Electrochemistry, Volume 4, Plenum press, 2001.
7. M.G. Fontanna and N.D. Greene, Corrosion Engineering, McGraw-Hill publishing, 1978
8. I.M. Hutchings, Tribology: Friction and Wear of Engineering Materials, CRC press, Boca Raton, 1992 D.O. Sprowds, Corrosion Testing and Evaluation, Corrosion Metals Hand book, vol. 13, 1986.

COURSE OUTCOMES:

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

CO1: various corrosion process involved in electrochemistry

CO2: working mechanism of various instrumentation techniques

CO3: various coating process,

CO4: applications of coatings towards environmental safety

CO5: industrial applications of coatings

Board of Studies (BoS) :
BOS of Physics was held on 30.6.22

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PS O2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 4 : Ensuring inclusive and equitable quality education for all persons and promote lifelong learning opportunities.

Statement : The modules and topics mentioned in this course are designed to ensure all inclusive and thorough education with equity to all persons and promote learning opportunities at all times.

OEEY 736	ENVIRONMENTAL CHEMISTRY	L	T	P	C
SDG: 13		3	0	0	3

COURSE OBJECTIVES:

To make the student conversant with

COB1: Understand the issue of chemicals based pollution.

COB2: Understand the chemicals mobility in aquatic systems.

COB3: Understand contaminating chemicals in air and their fate.

COB4: Understand the type of soil contaminants and provide remediation.

COB5: Identify emerging environmental contaminants including speciation

MODULE I FUNDAMENTALS 9

Stoichiometry and mass balance-Chemical equilibria, acid base, solubility product (Ksp) ,heavy metal precipitation, amphoteric hydroxides, CO_2 solubility in water and species distribution – Ocean acidification, Chemical kinetics , First order- 12 Principles of green chemistry.

MODULE II AQUATIC CHEMISTRY 9

Water and wastewater quality parameters- environmental significance and determination; Fate of chemicals in aquatic environment, volatilization, partitioning, hydrolysis, photochemical transformation– Degradation of synthetic chemicals - Metals, complex formation, oxidation and reduction , pE – pH diagrams, redox zones – sorption- Colloids, electrical properties, double layer theory, environmental significance of colloids, coagulation

MODULE III ATMOSPHERIC CHEMISTRY 9

Atmospheric structure – chemical and photochemical reactions – photochemical smog. Ozone layer depletion – greenhouse gases and global warming, CO2 capture and sequestration – acid rain- origin and composition of particulates. black carbon, air quality parameters determination.

MODULE IV SOIL CHEMISTRY 9

Nature and composition of soil - Clays- cation exchange capacity-acid base and ion-exchange reactions in soil – agricultural chemicals in soil-reclamation of contaminated land; salt by leaching- Heavy metals by electrokinetic remediation.

MODULE V EMERGING POLLUTANTS **9**

Heavy metals-chemical speciation –Speciation of Hg & As- endocrine disturbing chemicals- Pesticides, Dioxins & Furan, PCBs ,PAHs and Fluro compounds toxicity- Nano materials, CNT, titania, composites ,environmental applications.

L – 45; Total Hours –45

REFERENCES:

1. Sawyer, C.N., Mac Carty, P.L. and Parkin, G.F., "Chemistry for Environmental Engineering and Science", Tata McGraw – Hill, Fifth edition, New Delhi 2003.
2. Colin Baird„ Environmental Chemistry, Freeman and company, New York, 5th Edition,2012.
3. Manahan, S.E., "Environmental Chemistry", Ninth Edition, CRC press, 2009.
4. Ronald A. Hites ,"Elements of Environmental Chemistry", Wiley, 2nd Edition,2012.

COURSE OUTCOMES:

Students will be able to

CO1: In solving environmental issues of chemicals based pollution.

CO2: To determine chemicals mobility in aquatic systems.

CO3: To identify contaminating chemicals in air and their fate.

CO4: Understand the type of soil contaminants and provide remediation.

CO5: Identify emerging environmental contaminants including speciation

Board of Studies (BoS): 12th BoS of Chemistry held on 22.07.2022

Academic Council: 19th AC held on 29.09.2022

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO 1	M	H	M	M	M	H									
CO 2	M	H	M	M	M	H									
CO 3	M	H	M	M	M	H									
CO 4	M	H	M	M	M	H									
CO 5	M	H	M	M	M	H									

Note: L- Low Correlation M - Medium Correlation H -High Correlation

SDG 13: Climate Action: Take urgent action to combat climate change and its impacts

Statement: Understanding of environmental chemistry will lead to take necessary changes for maintaining a healthy environment.

OEEY 737	FUEL CELLS *F*OR SUSTAINABLE	L	T	P	C
SDG: 7,11	ENERGY PRODUCTION	3	0	0	3

COURSE OBJECTIVES:

The student will

COB1: familiar with the types of fuel cell

COB2: familiar with the components of fuel cells

COB3: understand the performance for fuel cells

COB4: learn the methods **of** production storage of hydrogen

COB5: learn the sustainability **and** applications of fuel cells

MODULE I INTRODUCTION AND TYPES OF FUEL CELLS 9

Introduction - definition - history - difference between batteries and fuel cells - chemistry of fuel cells - classification of fuel cell (based on temperature and electrolyte) - types of fuel cell: polymer electrolyte membrane or proton exchange membrane fuel cell (PEMFC), direct methanol fuel cell (DMFC), alkaline fuel cell (AFC), phosphoric acid fuel cell (PAFC), molten carbonate fuel cell (MCFC) and solid oxide fuel cells (SOFC)

MODULE II FUEL CELL COMPONENTS 9

Membrane electrode assembly components: membranes and ionomers, fuel cell electrodes and gas diffusion layer, fuel cell electrocatalysts (type and synthesis) - bi-polar plates, humidifiers and cooling plates - *phase-change materials* (PCMs) for thermal packaging - fuel cell stack - Balance of plant - Seals and insulation – Safety.

MODULE III FUEL CELLS PERFORMANCE AND APPLICATIONS 9

Thermodynamics of fuel cells - electrochemical kinetics of fuel cells - Fuel cell efficiency - performance characteristics: voltage efficiency - effect of voltage with current density for low and high temperature fuel cells - causes for voltage losses – introduction to fuel cycle analysis - Mass balance

MODULE IV PRODUCTION AND STORAGE OF HYDROGEN FUEL 9

Hydrogen as energy source - its merit as a fuel - hydrogen production: steam reforming, partial oxidation, coal gasification/thermal reforming, fuel cell technology based on bio-mass - hydrogen storage: compressed hydrogen,

liquid hydrogen, metal hydrides, carbon fibers - safety and management of hydrogen

MODULE V FUEL CELL APPLICATIONS AND SUSTAINABILITY 9

Fuel cell material recycle, durability, lifetime issues - Critical issues, adoption, future technologies - distributed power generation - grid-connect applications - non-grid connect applications - combined heat and power (CHP) - economic and environmental analysis - Control of contaminants: CO and sulphur - future trends of fuel cells - Sustainability of Hydrogen Fuel Cell Electric Vehicles.

L – 45; TOTAL HOURS – 45

TEXT BOOKS:

1. R.H. Thring (Editor), Fuel Cells for Automotive Applications, Professional Engineering Publishing UK, 2004.
2. Gregor Hoogers (Editor), Fuel Cell Technology Handbook, SAE International, CRC Press, 2003.
3. Vladimir S. Bagotsky, Fuel Cells: Problems and Solutions, 2nd Edition, John Wiley and Sons, 2012.
4. B. Viswanathan and M. Aulice Scibioh, Fuel Cells: Principles and Applications, Taylor and Francis Group, 2007.
5. Supramaniam Srinivasan, Fuel cells: From Fundamentals to Applications, Springer, 2006.
6. Prospects for Hydrogen and Fuel Cells, International Energy Agency, OECD Publishing, 2005.

COURSE OUTCOMES:

The student will be able to

CO1: classify fuel cells and elaborate the different types of fuel cells.

CO2: explain the components of the fuel cells and can synthesise electrocatalysts for the system

CO3: calculate the open circuit voltage, efficiency and voltage losses, explain fuel cycle analysis and mass balance

CO4: suggest the suitable methods of production and storage of hydrogen for fuel cells.

CO5: find application of fuel cells for variety of application and practice on sustainable environment

Board of Studies (BoS):
12th BoS of Chemistry held on 22.07.2022

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	L	M													
CO2		M			M										
CO3		M		L											
CO4	M		L			M									
CO5			M												

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 7: ensure access to affordable, reliable, sustainable and modern energy for all.
SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable

OEEY 738	GREEN AND SUSTAINABLE	L	T	P	C
SDG: 4, 7, 9	CHEMISTRY	3	0	0	3

COURSE OBJECTIVES:

To make the student conversant with

COB1: understand the principle and concepts of green chemistry

COB2: various alternative (non-traditional) reagents and chemicals for green synthesis.

COB3: understand the non-conventional energy sources for green synthesis

COB4: understand the uses of eco-benign solvents - alternative to organic solvents

COB5: synthesis of nanomaterials using green chemistry approaches

MODULE I INTRODUCTION, PRINCIPLE AND CONCEPTS OF GREEN CHEMISTRY 9

Need for green chemistry; Inception and evolution of green chemistry; Twelve principles of green chemistry with their explanations and examples; Designing a green synthesis using these principles; Green chemistry in day to day life.

MODULE II NON-TRADITIONAL GREENER ALTERNATIVE APPROACHES 9

Different approaches to green synthesis: (a) Uses of green reagents in organic synthesis - Dimethyl carbonate, polymer supported reagents - peracids and chromic acid; (b) Green catalysts, role of catalysis in sustainable development, homogeneous and heterogeneous catalysts; lntroduction, advantages and applications of (i) Nanocatalysts, (ii) Phase transfer catalysts, (iii) Biocatalysts, (iv) Organocatalysts, in organic synthesis.

MODULE III APPLICATIONS OF NON-CONVENTIONAL ENERGY SOURCES 9

Introduction of microwave induced synthesis: Microwave activation, equipment, time and energy benefits, and limitations. Organic transformations under microwaves - Fries rearrangement, Diels-Alder

reaction, decarboxylation, saponification of ester, alkylation of reactive methylene compounds; Heterocyclic synthesis - pyrrole, quinoline.
Introduction of ultrasound assisted green synthesis: Instrumentation, physical aspects, applications in organic transformations.

MODULE IV ENVIRONMENTALLY BENIGN SOLUTIONS TO ORGANIC SOLVENTS **9**

Ionic liquids as green solvents: Introduction, properties and types of ionic liquids. Synthetic applications Diels-Alder reaction, epoxidation and Heck reaction.
Aqueous phase reactions: Enhancement of selectivity, efficiency. Synthetic applications - 1,3-Dipolar Cycloadditions, Carbon-Carbon bond-forming processes and bromination reactions.
Fluorous solvents in green chemistry: Scope, definition and their synthetic applicability. Role of supercritical carbon dioxide in green chemistry.
Ethyl lactate as a renewable green solvent: Properties and applications.

MODULE V GREENER SYNTHESIS OF NANOMATERIALS **9**

Greener synthesis of Nanomaterials— Microwave assisted synthesis of Quantum Dots (QD) and nano catalysts in aqueous medium, Magnetic Nanoparticles. Synthesis of Nanoparticles using Bacteria, Yeast, Algae and Fungus.

L – 45; TOTAL HOURS –45

TEXT BOOKS:

1. Green Chemistry – Environmentally benign reactions – V. K. Ahluwalia. Ane Books India (Publisher). (2006).
2. Green Chemistry – Designing Chemistry for the Environment – edited by Paul T. Anastas & Tracy C. Williamson. Second Edition, (1998).
3. Green Chemistry – Frontiers in benign chemical synthesis and processes- edited by Paul T. Anastas & Tracy C. Williamson. Oxford University Press, (1998).
4. Green Chemistry – Environment friendly alternatives- edited by Rashmi Sanghi & M. M. Srivastava, Narora Publishing House, (2003).
5. Sheldon, R.A., Arends, I., and Hannefed, U., Green Chemistry and Catalysis, Wiley-VCH Verlag GmbH and Co. (2007).

6. Anastas, P., and Williamson, T. C., Green Chemistry Frontiers in Benign Chemical Synthesis and Processes, Oxford University Press (1999).
7. Ahluwalia, V. K., and Kidwai, M., New Trends in Green Chemistry, Anamaya Publishers (2004)

COURSE OUTCOMES:

The students will be able to

CO1: understanding of the 12 principles of green chemistry to improve the sustainability performance of the products/ materials

CO2: use various alternative reagents and chemicals for green synthesis.

CO3: apply non-conventional energy sources for the synthesis of organic compounds and materials.

CO4: use eco-begin solvents for the synthesis of organic compounds and materials

CO5: understand the synthesis of nanomaterials using greener methods

Board of Studies (BoS):
12th BoS of Chemistry held on 22.07.2022

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H				L										
CO2			M												
CO3		H						M							
CO4		H													
CO5				L						H					

Note: L- Low Correlation M - Medium Correlation H -High Correlation

SDG 4 & Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

SDG 7 & Ensure access to affordable, reliable, sustainable and modern energy for all.

`SDG 9 : Build resilient Infrastructure, promote inclusive and sustainable industrialization and foster innovation

Statement : The holistic understanding of green chemistry principles and concepts to sustainable development in the field of synthetic and materials chemistry.

OEEY 739	INDUSTRIAL POLLUTION	L	T	P	C
SDG: 6,7,9,11, 12,13 and 15	CONTROL	3	0	0	3

COURSE OBJECTIVES:

This course will enable students to:

COB1: understand the environmental pollution, environmental emission standards and the laws and rules.

COB2: understand the concept of pollution prevention.

COB3: Understand various air pollution control methods.

COB4: Understand various water pollution control methods of primary and secondary treatment.

COB5: understand the biological treatment, tertiary treatment and solid wastes disposal.

MODULE I EMISSION STANDARDS AND ENVIRONMENTAL LAWS **8**

Environment and environmental pollution from chemical process industries- Air pollutants and pollution and its effects- , characterization of emissions, water pollutants and pollution- and its effects- characterization of effluents- standards for ambient air, noise emission and effluents- Environmental Laws and rules : Air act 1981 and 1987, water act 1974,1977,1987, environmental protection act 1986, The hazardous wastes (management and handling) rules, 1989 & 2000, The manufacture, storage and import of hazardous chemical rules, 1989 & 2000, Public liability insurance act, 1991.The national environment tribunal act, 1995,The chemical accidents (emergency planning, preparedness and response rules, 1996, The recycled plastic manufacture and usage rules, 1999,The batteries (management and handling (draft) rules, 2000.

MODULE II POLLUTION PREVENTION **10**

Process modification: process change, technology change, better process control and product modification- alternative raw material - recovery of by-product from industrial emission effluents- waste reduction techniques: recycle and reuse of waste and volume reduction- energy recovery and

waste utilization- Material and energy balance for pollution minimization- Water use minimization- Fugitive emission/effluents and leakages and their control- LDAR programmes- housekeeping and maintenance.

MODULE III AIR POLLUTION CONTROL 9

Introduction to air pollution control- Particulate emission control by mechanical separation: gravitational settling chambers, cyclone separators, fabric filters and electrostatic precipitator and wet gas scrubbing, gaseous emission control by absorption and adsorption, Design of cyclones, ESP, fabric filters and absorbers.

MODULE IV WATER POLLUTION CONTROL 10

Introduction to Water Pollution and Control - Physical treatment, pre-treatment, solids removal by setting and sedimentation, filtration centrifugation, coagulation and flocculation Secondary treatment: Biological treatment- Anaerobic and aerobic treatment - Trickling filter, activated sludge and lagoons, aeration systems.

MODULE V TERTIARY TREATMENT AND SOLID DISPOSAL 8

Tertiary treatment: colour and odour removal - **Solids Disposal:** Sludge separation and drying- Solids waste disposal – composting, landfill, briquetting / gasificationand incineration.

L – 45; TOTAL HOURS – 45

TEXT BOOKS:

1. Paul N Cheremisinoff, Air pollution control and design for industry, 2018.
2. Rao. C.S, Environmental Pollution control Engineering, 2007.

REFERENCES:

1. Thomas T. Shen, Industrial Pollution Prevention, Springer, 1999.
2. Nancy J. Sell, Industrial Pollution Control: Issues and Techniques, 2nd Edition,Wiley, 1992.
3. Pollution Control Law Series: Pollution Control Acts, Rules and Notification Issued There under, Central Pollution Control Board, Ministry of Environment and Forest, Government of India, 2006.
4. www.moef.nic.in.

COURSE OUTCOMES:

Students will be able to describe

CO1: environmental pollution and the environmental standards.

CO2: the concept of pollution prevention.

CO3: various air pollution control methods.

CO4: The pre and secondary treatment of water pollution control methods.

CO5: various tertiary treatment and solid wastes disposal methods.

Board of Studies (BoS):
12th BoS of Chemistry held on 22.07.2022

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1			H												
CO2			H			M									
CO3					M										
CO4					M										
CO5					M										

Note: L- Low Correlation M - Medium Correlation H -High Correlation

SDG 7 : Ensure access to affordable, reliable, sustainable and modern energy for all

Statement: The holistic understanding of recycling materials and technology leads to provide modern renewable energy and sustainable industrialization.

OEEY 740	**INTRODUCTION TO EMBEDDED SYSTEM**	**L**	**T**	**P**	**C**
SDG: 4,9		**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

COB1: To describe the embedded system concepts with its hardware and software architectures.

COB2: To analyze the significance of memory and interrupts in an embedded system

COB3: To discuss the software development tools necessary for embedded systems.

COB4: To interpret the programming model in embedded system

COB5: To compare the concepts of OS and RTOS.

PREREQUISITES: Basics concepts of Microprocessor

MODULE I INTRODUCTION OF EMBEDDED SYSTEM 9

Introduction –Embedded Systems vs. General computing systems- Fundamental Components of embedded systems- Characteristics- Challenges-Examples- Embedded System design process.

MODULE II EMBEDDED COMPUTING PLATFORM 9

Overview of Processors and hardware units in an embedded system-CPU buses – Memory devices –Memory types- I/O devices – Interrupts and types.

MODULE III EMBEDDED SOFTWARE DEVELOPMENT PROCESS and TOOLS 9

Development process of an embedded system-software modules and tools for implementation of an embedded system- Integrated development environment- Host and target machines-cross compiler-cross assembler-Debugging mechanisms.

MODULE IV PROGRAM MODELING IN EMBEDDED SYSTEMS 9

Program Models – Data Flow Graph model-control DFG model-Synchronous DFG model- Finite state machines- UML modeling – UML Diagrams.

MODULE V REAL TIME OPERATING SYSTEMS (RTOS) 9

Overview of Operating Systems (OS) concepts – Real time systems –Types -Need for RTOS in Embedded Systems -Compare OS and RTOS- Multiple Tasks and Multiple Processes-Priority-Based Scheduling- Real time scheduling algorithm –Inter process Communication Mechanisms- Case study.

L –45 ; TOTAL HOURS –45

TEXT BOOKS:

1. Marilyn Wolf, "Computers as components ", Elsevier, 2016.
2. K.V. Shibu , Introduction to Embedded Systems, McGraw Hill Education India Private Limited; Second edition, 2017.

REFERENCES:

1. Qing Li and Carolyn Yao, "Real-Time Concepts for Embedded Systems", CMP Books, 2003.

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1: identify the suitable processor and peripherals for embedded applications

CO2: discuss the software development tools and process.

CO3: draw the programming model for embedded systems

CO4: analyze the role of RTOS for embedded applications

CO5: design real time embedded application.

Board of Studies (BoS) : 24th BOS of ECE held on 08.02.2023.

Academic Council: 20th AC held on 13.04.2023

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	H	H	H	H	H	M	M	M	M	M	M	H	H	H
CO2	H	H	H	H	H	H	M	M	M	M	M	M	H	H	H
CO3	H	H	H	H	H	H	M	M	M	M	M	M	H	H	H
CO4	H	H	H	H	H	H	M	M	M	M	M	M	H	H	H
CO5	H	H	H	H	H	H	M	M	M	M	M	M	H	H	H

Note: L- Low Correlation M - Medium Correlation H -High Correlation

SDG 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
Statement: Understanding of the real time systems will bring practical knowledge on quality education.

SDG 9: Build resilient Infrastructure, promote inclusive and sustainable industrialization and foster innovation
Statement: capable of promoting industrialization through the application of real-time system design principles.

OEEY 741	MATLAB PROGRAMMING	L	T	P	C
SDG: 9		3	0	0	3

COURSE OBJECTIVES:

COB1: To create the mathematical model for specific systems

COB2: Discuss the computer tools to solve mathematical models for specific systems.

COB3: Develop models to solve linear and non linear differential equations

COB4: To define the system or process through MATLAB

COB5: To describe MATLAB graphic feature and its applications.

PREREQUISITES: Mathematics

MODULE I INTRODUCTION TO MATLAB AND DATA PRESENTATION **9**

Introduction to MATLAB-Vectors, Matrices -Vector/Matrix Operations & Manipulation Functions vs scripts- Making clear and compelling plots-Solving systems of linear equations numerically and symbolically.

MODULE II ROOT FINDING AND MATLAB PLOT FUNCTION **9**

Linearization and solving non-linear systems of equations- The Newton-Raphson method- Integers and rational numbers in different bases- Least squares regression - Curve fitting-Polynomial fitting and exponential fitting.

MODULE III LINEAR AND NON-LINEAR DIFFERENTIAL EQUATIONS **9**

Numerical integration and solving first order, ordinary differential equations (Euler's method and Runge-Kutta)- Use of ODE function in MATLAB-Converting second order and higher ODEs to systems of first order ODEs-Solving systems of higher order ODEs via Euler's method and Runge-Kutta)-Solving single and systems of non-linear differential equations by linearization-Use of the function ODE in MATLAB to solve differential equations - Plot Function –Saving & Painting Plots.

MODULE IV INTRODUCTION OF SIMULINK **9**

Simulink & its relations to MATLAB – Modeling a Electrical Circuit- Modeling a fourth order differential equations- - Representing a model as a subsystem- Programme specific Simulink demos.

MODULE V APPLICATION OF MATLAB 9

Linear algebraic equations – elementary solution method – matrix method for linear equation – Cramer's method – Statistics, Histogram and probability – normal distribution – random number generation – Interpolation – Analytical solution to differential equations – Numerical methods for differential equations.

L –45 ; TOTAL HOURS –45

TEXT BOOKS:

1. Attaway, Stormy. Matlab: a practical introduction to programming and problem solving. Butterworth-Heinemann, 2013.
2. Chapra, Steven. EBOOK: Applied Numerical Methods with MATLAB for Engineers and Scientists. McGraw Hill, 2011.
3. Singh, Harendra, Devendra Kumar, and DumitruBaleanu, eds. Methods of mathematical modelling: fractional differential equations. CRC Press, 2019.

REFERENCES:

1. Hossain, Eklas. "Introduction to Simulink." In MATLAB and Simulink Crash Course for Engineers, Springer International Publishing, 2022.
2. Sumathi, Sai, and Surekha Paneerselvam. Computational intelligence paradigms: theory & applications using MATLAB. CRC Press, 2010.

COURSE OUTCOMES:

On completion of the course, students will be able to

CO1: analyze mathematical model for specific systems

CO2: develop a code for specific tasks.

CO3: write MATLAB programs for solving linear and nonlinear systems

CO4: model a specific system using simulink

CO5: apply built in functions for the wide range of applications

Board of Studies (BoS) : 24th BOS of ECE held on 08.02.2023.

Academic Council: 20th AC held on 13.04.2023

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO11	PO 12	PSO1	PSO2	PSO3

CO1	H	H	M	M	L	L	L	L	L	L	L	L	H	H	H
CO2	M	H	M	M	L	L	L	L	L	L	L	L	H	H	H
CO3	M	M	L	M	L	L	L	L	L	L	L	L	H	H	H
CO4	H	M	M	M	L	L	L	L	L	L	L	L	H	H	H
CO5	H	H	M	M	L	L	L	L	L	L	L	L	H	H	H

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 9 : Build resilient Infrastructure, promote inclusive and sustainable industrialization and foster innovation

Statement : Describes the methodology to apply modern tools for solving the mathematical models which promotes sustainable industrialization and foster innovation

OEEY 710	NANOTECHNOLOGY AND	L	T	P	C
SDG: 6,7,9,15	CATALYSIS	3	0	0	3

COURSE OBJECTIVES:

To make the student conversant with

COB1: basic knowledge on nanoscience and nanotechnology which includes the exotic properties of materials at nanoscale including various techniques for the processing of nanomaterials

COB2: various techniques available for the characterization of nanostructured materials

COB3: applications in selected fields and impacts of nanotechnology in ecosystem

COB4: Impart the basic concepts involved in catalytic processes.

COB5: Understand the importance of heterogeneous catalysis.

MODULE I INTRODUCTION AND PREPARATION OF NANOMATERIALS **9**

Introduction to nanomaterials, Properties of nanomaterials, Nanostructures: Zero-, One-, Two- and Three-dimensional structures, Surface Plasmon Resonance, Change of bandgap; Methods of preparation of nanomaterials, top-down approach and bottom-up: Chemical precipitation and coprecipitation; Sol-gel synthesis; Ball milling synthesis; lithography, Plasma Laser deposition (PLD) techniques, Thermolysis routes (Solvothermal, Hydrothermal and pyrolysis), Microwave assisted synthesis; Sonochemical synthesis; Electrochemical synthesis.

MODULE II CHARACTERIZATION TECHNIQUES **9**

Structural Characterization: X-ray diffraction, Scanning Electron Microscopy (SEM/HR-SEM/FE-SEM) with EDS, TEM (HR-TEM) and SAED analysis, Atomic force Microscopy (AFM). X-ray Photoelectron spectroscopy (XPS), Raman analysis. Introduction to advanced Scanning Probe Microscopy Techniques Scanning Tunnelling Mode (STM), Piezoelectric force microscopy (PFM). DLS and zeta potential analysis. BET surface area analysis, CHNSO micro analysis.

MODULE III APPLICATIONS AND ENVIRONMENTAL IMPACTS 9

Current applications - Short-term Applications - Long - term Applications – Energy filed - solar cells, military battle suits. Biomedical applications – Photodynamic therapy in targeted drugs - quantum dot technology in cancer treatment, MRI applications. Nanosensors: pH, heat, humidity, gas, toxic chemicals sensors and sensors for aerospace and defence – biosensors – water remediation - Environmental Impacts: toxicological health effects, relevant parameters in nanoparticles toxicology, integrated concept of risk assessment of nanoparticles.

MODULE IV CONCEPTS OF CATALYSIS 9

Acid-base catalysis – catalysis by transition metal ions and their complexes – supported transition metal complexes as catalysts – catalysis by enzymes – phase transfer catalysis - photocatalysis – adsorption – chemisorption on metals, metal oxides and semiconductors - kinetics of unimolecular and bimolecular surface reactions - Contact time - WHSV - time on stream - Catalyst deactivation and regeneration, TOF, TON.

MODULE V HETEROGENEOUS CATALYSTS 9

Metals, metal oxides, mixed metal oxides, supported metals, spinels, perovskites, super acids, hydrotalcites, zeolites and zeotypes (small, medium, large), shape selective catalysts, mesoporous materials (SBA, MCM, KIT, AlPOs, MOFs, COFs) Hydrothermal synthesis, sol-gel process, impregnation method, ion-exchange method - Operations in catalyst manufacture - drying, calcination, spray drying, Reactors- fixed bed and flow reactors.

L – 45; TOTAL HOURS – 45

REFERENCES:

1. T. Pradeep, Nano: The Essentials, Tata McGraw-Hill, New Delhi, 2007.
2. G. Cao, Nanostructures and Nanomaterials –Synthesis, Properties and Applications, Imperial College Press, London, 2004.
3. C. N. R. Rao, A. Muller and A. K. Cheetham, The Chemistry of Nanomaterials, Volume 1, Wiley –VCH Verlag GmbH & Co. KgaA, Weinheim, 2004.
4. G. A. Ozin, A. C. Aresnault, L. Cadematriri, Nanochemistry: A chemical approach to nanomaterials, RSC Publishing, 2008

5. J. Rajaram and J.C. Kuriacose, Kinetics and Mechanisms of Chemical Transformations, Macmillan Publishers India Limited, 2000.
6. B. Viswanathan, S. Sivasanker and A.V. Ramaswamy (Editors), Catalysis

COURSE OUTCOMES:

The students will be able to

CO1: differentiate the nanomaterials based on their dimensions and acquire knowledge of various synthetic methods

CO2: understand the components of instrumental techniques of and characterization techniques for structural and properties of nanomaterials

CO3: select the appropriate nanomaterials for specific applications in the interested arena

CO4: Find the fundamentals of catalysis

CO5: Evaluate significance of heterogeneous catalysts.

Board of Studies (BoS): 12th BoS of Chemistry held on 22.07.2022

Academic Council: 19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1		L		M	H	H									
CO2	M			H	M	H									
CO3					H	M									
CO4															
CO5															

Note: L- Low Correlation M - Medium Correlation H -High Correlation

SDG 6: Clean Water and Sanitation
SDG 7: Affordable & Clean Energy
SDG 9 : Industry and Innovation
SDG 15 : Life on Land
Statement:
SDG 6, 7 & 9: Foundation to work in R&D of renewable energy and sensors sector and for teaching career.
SDG 15: R&D labs in API labs in the production novel materials for various applications

OEEY 715	STRUCTURAL INTERPRETATION OF	L	T	P	C
SDG: 4, 9	MATERIALS	3	0	0	3

COURSE OBJECTIVES:

To use the concepts (basic and advanced level) of analytical methods for structure elucidation of materials and the students will be trained for the

COB1: Interpretation of electronic spectral data of materials

COB2: Interpretation of magnetic spectral data of materials

COB3: Interpretation of structural and morphological data of materials

COB4: Interpretation of thermos analytical data of materials

COB5: Interpretation of electrochemical and XPS data of materials

MODULE I ELECTRONIC DATA 9

UV-visible, fluorescence and phosphorescence: Characteristic absorption of simple chromophoric groups, conjugated/ aromatic/ ligand systems, metal complexes and materials. FT-IR and Raman: Characteristic group frequencies of organic, inorganic molecules and various materials (polymer, nano, semiconducting) Interpretation of organic and inorganic and hybrid materials using combination of the spectral data.

MODULE II MAGNETIC AND MASS DATA 9

Solid-state nuclear magnetic resonance spectroscopy: Compounds containing ^{1}H, ^{13}C, ^{19}F,^{27}Al, ^{29}Si, and ^{31}P nuclei. Electron spin resonance (ESR): Simulation of ESR spectra of paramagnetic species, spin dynamics in solid and liquid. Mass spectrometry: The production and analysis of positive ions, molecular ions, application of isotopic abundance measurements, fragmentation modes and rearrangement of ions. Interpretation of organic, inorganic compounds and materials using combination of the spectral data.

MODULE III STRUCTURAL AND MORPHOLOGICAL DATA 9

Fundamental theoretical framework for diffraction (XRD) and imaging methods (SEM, TEM and AFM) used in structural and compositional characterization of materials in solid, film state etc.

MODULE IV THERMOANALYTICAL DATA AND SURFACE AREA 9

Interpretation of Differential Thermal Analysis (DTA), Thermo-gravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC) data of various materials including inorganic complex, organic polymeric materials, composite, nano-composites etc; Surface area analysis; isotherms, types, BET surface area, pore dimensions, pore volume, etc.

MODULE V ELECTROCHEMICAL AND XPS DATA 9

Cyclic voltammetry for oxidation and reduction potentials, TAFEL polarization and Impedance spectroscopy for corrosion inhibitor behavior, chronoamperometry for charge or discharge of battery. X-ray photoelectron spectroscopy: Study the chemical composition and oxidation state of elements at the surface and interface. Applications of XPS in various arenas.

L – 45; TOTAL HOURS – 45

TEXT BOOKS:

1. R. S. Drago, Physical Methods for Chemists, W. B. Saunders,1992.
2. R. M. Silverstein, C. G. Bassler and T. C. Morril, Spectrophotometric Identification of Organic Compounds, 5th edition, Wiley, 1991.
3. D. H. Williams and I. Fleming, Spectroscopic Methods in Organic Chemistry, 3rd edition, McGraw Hill, 1980.
4. W. Kemp, Organic Spectroscopy, ELBS, 1979.
5. W. L. Jolly, The synthesis and characterization of inorganic compounds, Prentice-Hall, 1970.
6. John Wertz, Electron Spin Resonance: Elementary Theory and Practical Applications, Springer Science & Business Media, 2012.
7. R. F. Speyer, Thermal Analysis of Materials, CRC Press, 1994.
8. P.J. Goodhew, J. Humphreys and R. Beanland, Electron Microscopy and Analysis, Taylor & Francis, 2001.
9. John F Watts, John Woistenhoime, An introduction to surface analysis by XPS and AES, John Wiley and Sons, 2nd edition, 2003.
10. James, B. Condon, Surface Area and Porosity Determinations by Physisorption Measurement and Theory, Elsevier, 1st edition, 2006.

COURSE OUTCOMES:

The students will be able to

CO1: Interpret electronic spectral data of materials

CO2: Interpret magnetic spectral data of materials

CO3: Interpret structural and morphological data of materials

CO4: Interpret thermo analytical data and porous nature of materials

CO5: Interpret electrochemical and XPS data of materials

Board of Studies (BoS):
12th BoS of Chemistry held on 22.07.2022

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO1 1	PO1 2	PSO1	PSO2	PSO3
CO1	H	M		H	M	H									
CO2	H	M		H	M	L									
CO3	H	L		H	M	M									
CO4	H	L		H	M	H									
CO5	H	L		H	M	L									

Note: L- Low Correlation M - Medium Correlation H -High Correlation

SDG 4: Quality Education
SDG 9: Industry and Innovation

Statement:
SDG9: Foundation to work in R&D laboratory, chemical industry, independent researcher and for teaching career.
SDG4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities.

OEEY 742	SURFACE COATING	L	T	P	C
SDG: 9	TECHNOLOGY	3	0	0	3

COURSE OBJECTIVES:

To make the student conversant with

COB1: basic principles of surface chemistry

COB2: various coating techniques including CVD

COB3: industrial coatings and sputtering techniques

COB4: surface coating resins and emulsions

COB5: techniques like laser alloying and electron beam coating

MODULE I SURFACE CHEMISTRY OF ALLOYS 9

Basic physical chemistry, surface chemistry, pretreatment principle - technology and control of electro deposition systems such as alloy plating, electrolysis, composites.

MODULE II METHODS OF COATING I 9

Hot dip coatings - principle, surface preparation, methods, applications, Diffusion coatings - Principle - Cementation - Cladding - case hardening - structures.

Chemical vapor deposition - classification-techniques, metal organic type, plasma assisted, layer assisted, applications.

MODULE III METHODS OF COATING II 9

Industrial coatings like Enamels, Primers, Putties, Lacquers, Water based paints, Inks, HDPCs, Conversion coatings.

Sputtering techniques, methods, applications, plasma treatments, nitriding, carbonizing, boriding, titanizing methods and applications.

MODULE IV SURFACE COATING RESINS 9

Synthesis & characterization of various surface coating resins like Hard resins, Alkyds, Varnishes, Polyesters, Epoxies, Polyamides, Acrylics, Amino resins, CNSL resin, emulsions & water reducible resins.

MODULE V LASER ALLOY AND ELECTRON BEAM COATING 9

Laser alloying - sources, variables, methods, applications, Electron beam coating- evaporation materials, methods, applications.

L – 45; TOTAL HOURS – 45

REFERENCES:

1. G. Braco, Surface Science Techniques, Springer-Verlag Berlin and Heidelberg GmbH & Co. K, 2000.
2. T.S. Sudarsan, Surface Modification Technologies, Marcel Dekker Inc., 1989
3. D.R. Gabe, Principles of Metal Surfaces Treatment and Protection, Pergmon Press 1972.
4. Tracton, Coatings Technology, CRC press, 2006.

COURSE OUTCOMES:

The students will be familiar with

CO1: the pretreatment methods of electrodeposition

CO2: coating methods like, hot dipping, cementation, cladding. Advanced techniques like CVD, plasma assisted, layer assisted methods are also learnt by the students.

CO3: composition and characteristics of industrial coatings including enamels, primers etc.

CO4: synthesis and characterization of resins, emulsions etc

CO5: in detail knowledge about laser alloying, and electron beam coating and their applications in various fields.

Board of Studies (BoS):
12th BoS of Chemistry held on 22.07.2022

Academic Council:
19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1		H				M									
CO2		H			M										
CO3			L			H									
CO4	M				L										
CO5				M		H									

Note: L- Low Correlation M - Medium Correlation H -High Correlation

SDG 9 : Industry, Innovation and Infrastructure

SDG9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

OEEY 743	**THIN FILM SCIENCE AND TECHNOLOGY**	**L**	**T**	**P**	**C**
SDG: 4		**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

COB1: To familiarize with preparation and properties of thin films.

COB2: To understand the different kinetics of thin film nucleation.

COB3: To understand the characterization tools for thin films.

COB4: To study the different properties of thin films.

COB5: To apply the knowledge of thin film technology into applications.

MODULE I PREPARATION OF THIN FILMS 9

Kinetic aspects of gases in a vacuum chamber – classifications of vacuum ranges – production of vacuum - pressure measurement in vacuum systems– thin film (epitaxy) – definition – types of epitaxy. Different Growth Techniques: Liquid phase epitaxy – vapour phase epitaxy – molecular beam epitaxy – metal organic vapour phase epitaxy – sputtering (RF & DC) – pulsed laser deposition. Thickness Measurement: Microbalance technique – photometry-ellipsometry– interferometry.

MODULE II KINETICS OF THIN FILMS 9

Nucleation Kinetics: types of nucleation – kinetic theory of nucleation – energy formation of a nucleus – critical nucleation parameters; spherical and non spherical (cap, disc and cubic shaped) Growth Kinetics: Kinetics of binary (GaAs, InP, etc.), ternary (Al1-xGaxAs, Ga1-xInxP, InAs1-xPx, etc.) and quaternary (Ga1-xInxAs1 - yPy, etc.) semiconductors – derivation of growth rate and composition expressions.

MODULE III CHARACTERIZATION 9

X-ray diffraction – photoluminescence – UV-Vis-IR spectrophotometer – Atomic Force Microscope – Scanning Electron Microscope – Hall effect – Vibrational Sample Magnetometer – Secondary Ion Mass Spectrometry – X-ray Photoemission Spectroscopy.

MODULE IV PROPERTIES OF THIN FILMS 9

Dielectric properties – experimental technique for the determination of dielectric properties – optical properties – experimental technique for the determination of optical constants – mechanical properties – experimental technique for the determination of mechanical properties of thin films – magnetic and superconducting properties.

MODULE V APPLICATIONS 9

Optoelectronic devices: LED and Solar cell – Micro Electromechanical Systems (MEMS) – Fabrication of thin film capacitor – application of ferromagnetic thin films; data storage, Giant Magnetoresistance (GMR) – sensors – fabrication and characterization of thin film transistor and FET – quantum dot - Cryptography.

L – 45; TOTAL HOURS –45

REFERENCES:

6. Goswami. A, Thin Film Fundamentals, New Age International (P) Limited, New Delhi, 1996.
7. AichaEishabini-Riad, Fred D. Barlow and ISHN, Thin film Technology Handbook, McGraw-Hill Professional Publishers, 1997.
8. Krishna Seshan, Handbook of Thin Film Deposition, William Andrew Publishers, 2012.
9. Donald Smith, Thin-Film Deposition: Principles and Practice, McGraw-Hill Professional Publishers, 1995.
10. K.L.Chopra, “Thin Film Phenomena”, Malabar: Robert E. Krieger Publishing Company, 1979.

COURSE OUTCOMES:

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

CO1: the basic concepts about the thin film technology

CO2: the different kinetics of thin film nucleation.

CO3: the characterization tools for thin films.

CO4: Structural, optical, dielectric and mechanical properties of thin films

CO5: applications of thin films in optoelectronics

Board of Studies (BoS) : BOS of Physics was held on 30.6.22

Academic Council: 19th AC held on 29.09.2022

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PS O2	PS O3
CO1	H	M	L	L	M	M	M	L	L	L	M	M	M	M	M
CO2	H	M	M	L	L	M	L	L	L	L	L	M	M	M	M
CO3	H	M	M	L	L	L	L	L	L	L	L	M	M	M	M
CO4	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M
CO5	H	M	M	L	M	M	M	L	L	L	M	M	M	M	M

Note: L- Low Correlation M -Medium Correlation H -High Correlation

SDG 4 : Ensuring inclusive and equitable quality education for all persons and promote lifelong learning opportunities.

Statement : The modules and topics mentioned in this course are designed to ensure all inclusive and thorough education with equity to all persons and promote learning opportunities at all times.