UNIVERSITY VISION AND MISSION

VISION

B.S. Abdur Rahman Institute of Science and Technology aspires to be a leader in Education, Training and Research in Engineering, Science, Technology and Management and to play a vital role in the socio-Economic progress of the Country.

MISSION

- To blossom into an internationally renowned University
- To empower the youth through quality education and to provide professional leadership
- 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 THE 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. Materials Science

PROGRAMME EDUCATIONAL OBJECTIVES:

- To provide theoretical and practical knowledge in the broad area of materials science
- To provide an exposure on synthesis, characterization and testing of various engineering materials.
- To provide knowledge on the various applications of different classes of materials.
- To provide a thorough understanding of the mechanism contributing to various properties of materials.

PROGRAMME OUTCOMES

On completion of program, the graduates will

- Possess sound knowledge about the physics of different classes of materials.
- Have expertise in various characterization and testing methods.
- Be able to choose appropriate material for various applications.
- Be able to modify the properties to satisfy functional requirements.
- Be capable of pursuing life long learning and research in the broad field of materials science.

B.S.ABDUR RAHMAN UNIVERSITY

B.S. ABDUR RAHMAN INSTITUTE OF SCIENCE & TECHNOLOGY
(Estd.u/s 3 of the UGC Act, 1956)

(FORMERLY B.S.ABDUR RAHMAN CRESCENT ENGINEERING COLLEGE)
Seethakathi Estate, G.S.T. Road, Vandalur, Chennai - 600 048.

REGULATIONS 2013
FOR
M.TECH. DEGREE PROGRAMMES
(WITH AMENDMENTS INCORPORATED TILL JUNE 2015)

B.S. ABDUR RAHMAN UNIVERSITY, CHENNAI 48.

REGULATIONS -2013 FOR M.TECH / MCA / M.Sc. DEGREE PROGRAMMES

(With amendments incorporated till June 2015)

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.)

ii) **"Course"** means a theory or practical subject that is normally studied in a semester, like Applied Mathematics, Structural Dynamics, Computer Aided Design, etc.

iii) **"University"** means B.S.Abdur Rahman University, Chennai, 600048.

iv) **"Institution"** unless otherwise specifically mentioned as an autonomous or off campus institution means B.S.Abdur Rahman University.

v) **"Academic Council"** means the Academic Council of this University.

vi) **"Dean (Academic Affairs)"** means Dean (Academic Affairs) of B.S.Abdur Rahman University.

vii) **"Dean (Student Affairs)"** means Dean(Student Affairs) of B.S.Abdur Rahman University.

viii) **"Controller of Examinations"** means the Controller of Examinations of B.S.Abdur Rahman University who is responsible for conduct of examinations and declaration of results.

2.0 PROGRAMMES OFFERED, MODE OF STUDY AND ADMISSION REQUIREMENTS

2.1 P.G. Programmes Offered

The various P.G. Programmes and their modes of study are as follows:

Degree	**Mode of Study**
M.Tech.	Full Time
M.Tech.	Part Time – Day / Evening
M.C.A.	Full Time
M. Sc.	Full Time
M. Sc.	Full Time

2.2 MODES OF STUDY

2.2.1 Full-time

Students admitted under "Full-Time" shall be available in the Institution during the complete working hours for curricular, co-curricular and extra-curricular activities assigned to them.

2.2.2 A full time student, who has completed all non-project courses desiring to do the Projectwork in part-time mode for valid reasons, shall apply to the Dean (Academic Affairs) through the Head of the Department, if the student satisfies the clause 2.3.4 of this Regulation. Permission may be granted based on merits of the case. Such conversion is not permitted in the middle of a semester.

2.2.3 Part time - Day time

In this mode of study, the students are required to attend classes for the courses registered along with full time students.

2.2.4 Part time - Evening

In this mode of study, the students are required to attend normally classes in the evening and on Saturdays, if necessary.

2.2.5 A part time student is not permitted to convert to full time mode of study.

2.3 ADMISSION REQUIREMENTS

2.3.1 Students for admission to the first semester of the Master's Degree Programme shall be required to have passed the appropriate degree examination of this University as specified in the Table shown for eligible entry qualifications for admission to P.G. programmes or any other degree examination of any University or authority accepted by this University as equivalent thereto.

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

2.3.3 All part-time students should satisfy other conditions regarding experience, sponsorship etc., which may be prescribed by this Institution from time to time.

2.3.4 A student eligible for admission to M.Tech. Part Time / Day Time programme shall have his/her permanent place of work within a distance of 65km from the campus of this Institution.

2.3.5 Student eligible for admission to M.C.A under lateral entry scheme shall be required to have passed three year degree in B.Sc (Computer Science) / B.C.A / B.Sc (Information Technology)

3.0 DURATION AND STRUCTURE OF THE P.G. PROGRAMME

3.1 The minimum and maximum period for completion of the P.G. Programmes are given below:

Programme	**Min.No.of Semesters**	**Max.No.of Semesters**
M.Tech. (Full Time)	4	8
M.Tech.(Part Time)	6	12
M.C.A. (Full Time)	6	12
M.C.A. (Full Time) – (Lateral Entry)	4	8
M.Sc. (Full Time)	4	8

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

i. Core courses

ii. Elective courses

iii. Project work / thesis / dissertation

iv. Laboratory Courses

v. Case studies

vi. Seminars

vii. Industrial Internship

3.3 The curriculum and syllabi of all PG. programmes shall be approved by the Academic Council of this University.

3.4 The minimum number of credits to be earned for the successful completion of the programme shall be specified in the curriculum of the respective specialization of the P.G. programme.

3.5 Each academic semester shall normally comprise of 80 working days. Semester-end examinations will follow immediately after the last working day.

ELIGIBLE ENTRY QUALIFICATIONS FOR ADMISSION TO P.G. PROGRAMMES

Sl. No.	Name of the Department	P.G. Programmes offered	Qualifications for admission
01.	Civil Engineering	M.Tech. (Structural Engineering)	B.E / B.Tech. (Civil Engineering) / (Structural Engineering)
		M.Tech. (Construction Engineering and Project Management)	
02.	Mechanical Engineering	M.Tech. (Manufacturing Engineering)	B.E. / B.Tech. (Mechanical / Auto / Manufacturing / Production / Industrial / Mechatronics / Metallurgy / Aerospace /Aeronautical / Material Science / Marine Engineering)
		M.Tech. CAD / CAM	
03.	Polymer Engineering	M.Tech. (Polymer Technology)	B.E./ B.Tech. degree Mech./Production/ Polymer Science or Engg or Tech / Rubber Tech / M.Sc (Polymer Sc./ Chemistry Appl. Chemistry)
04.	Electrical and Electronics Engineering	M.Tech. (Power Systems Engg)	B.E / B.Tech (EEE / ECE / E&I / I&C / Electronics / Instrumentation)
		M.Tech. (Power Electronics & Drives)	
05.	Electronics and Communication Engineering	M.Tech. (Communication Systems)	B.E / B.Tech (EEE/ ECE / E&I / I&C / Electronics / Instrumentation)
		M.Tech.(VLSI and Embedded Systems)	B.E./ B.Tech. in ECE / Electronics / EIE / ICE / EEE
		M.Tech.(Signal Processing)	
06.	ECE Department jointly with Physics Dept	M.Tech. (Optoelectronics and Laser Technology)	B.E./B.Tech. (ECE / EEE / Electronics / EIE / ICE) M.Sc (Physics / Materials Science / Electronics / Photonics)
07.	Electronics and Instrumentation Engineering	M.Tech. (Electronics and Instrumentation Engineering)	B.E./ B.Tech. (EIE/ICE/Electronics/ECE/ EEE)
08.	Computer Science and Engineering	M.Tech. (Computer Science and Engineering)	B.E. /B.Tech. (CSE/IT/ECE/EEE/EIE/ICE/ Electronics) MCA
		M.Tech. (Software Engineering)	B.E. / B.Tech. (CSE / IT) MCA
		M.Tech (Network Security)	B.E. /B.Tech. (CSE/IT/ECE/EEE/EIE/ICE/ Electronics) MCA
		M.Tech (Computer and Predictive Analytics)	
		M.Tech. (Computer Science and Engineering with specialization in Big Data Analytics)	
09	Information Technology	M.Tech. (Information Technology)	B.E /B.Tech. (IT/CSE/ECE/EEE/EIE/ICE/ Electronics) MCA
		M.Tech. (Information Security & Digital Forensics)	

ELIGIBLE ENTRY QUALIFICATIONS FOR ADMISSION TO P.G. PROGRAMMES

Sl. No.	Name of the Department	P.G. Programmes offered	Qualifications for admission
10	Computer Applications	M.C.A.	Bachelor Degree in any discipline with Mathematics as one of the subjects (or) Mathematics at +2 level
		M.C.A. (Full Time) – (Lateral Entry)	B.Sc Computer Science / B.Sc Information Technology / B.C.A
		M.Tech. (Systems Engineering and Operations Research)	BE / B.Tech. (Any Branch) or M.Sc., (Maths / Physics / Statistics / CS / IT / SE) or M.C.A.
		M.Tech. (Data & Storage Management)	
11	Mathematics	M.Sc. (Actuarial Science)	Any Degree with Mathematics / Statistics as one of the Subjects of Study.
		M.Sc. Mathematics	B.Sc. (Mathematics)
12	Physics	M.Sc.(Physics)	B.Sc.(Physics / Applied Science / Electronics / Electronics Science / Electronics & Instrumentation)
		M.Sc. (Material Science)	
13	Chemistry	M.Sc.(Chemistry)	B.Sc (Chemistry) of B.Sc. (Applied Science)
14	Life Sciences	M.Sc. Molecular Biology & Biochemistry	B.Sc. in any branch of Life Sciences
		M.Sc. Genetics	B.Sc. in any branch of Life Sciences
		M.Sc. Biotechnology	B.Sc. in any branch of Life Sciences
		M.Sc. Microbiology	B.Sc. in any branch of Life Sciences
		M.Sc. Bioscience	B.Sc. in any branch of Life Sciences
		M.Tech. Biotechnology	B.Tech. (Biotechnology / Chemical Engineering) / M.Sc. in any branch of Life Sciences

3.6 The curriculum of PG 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	Minimum prescribed credit range
M.Tech.	75 to 85
M.C.A.	120 to 130
M.Sc.	75 to 85

3.7 Credits will be assigned to the courses for all P.G. programmes as given below:

* One credit for one lecture period per week
* One credit for one tutorial period per week
* One credit each for seminar/practical session/project of two or three periods per week
* One credit for two weeks of industrial internship.

3.8 The number of credits registered by a student in non-project semester and project semester should be within the range specified below:

P.G. Programme	Non-project Semester	Project semester
M.Tech. (Full Time)	15 to 29	12 to 20
M.Tech. (Part Time)	6 to 18	12 to 16
M.C.A. (Full Time)	15 to 29	12 to 20
M.Sc. (Full Time)	15 to 25	12 to 20

3.9 The electives from the curriculum are to be chosen with the approval of the Head of the Department.

3.10 A student may be permitted by the Head of the Department to choose electives offered from other PG programmes either within the Department or from other Departments up to a maximum of three courses during the period of his/her study, provided the Heads of the Departments offering such courses also agree.

3.11 To help the students to take up special research areas in their project work and to enable the department to introduce courses in latest/emerging areas in the curriculum, "Special Electives" may be offered. A student may be permitted to register for a "Special Elective" up to a maximum of three credits during the period of his/her study, provided the syllabus of this course is recommended by the Head of the Department and approved by the Chairman, Academic Council before the commencement of the semester, in which the special elective course is offered. Subsequently, such course shall be ratified by the Board of Studies and Academic Council.

3.12 The medium of instruction, examination, seminar and project/thesis/ dissertation reports will be English.

3.13 Industrial internship, if specified in the curriculum shall be of not less than two weeks duration and shall be organized by the Head of the Department.

3.14 PROJECT WORK/THESIS/DISSERTATION

3.14.1 Project work / Thesis / Dissertation shall be carried out under the supervision of a qualified teacher in the concerned Department.

3.14.2 A student may however, in certain cases, be permitted to work for the project in an Industrial/Research Organization, on the recommendation of the Head of the Department. In such cases, the project work shall be jointly supervised by a faculty of the Department and an Engineer / Scientist from the organization and the student shall be instructed to meet the faculty periodically and to attend the review committee meetings for evaluating the progress.

3.14.3 Project work / Thesis / Dissertation (Phase - II in the case of M.Tech.) shall be pursued for a minimum of 16 weeks during the final semester, following the preliminary work carried out in Phase-1 during the previous semester.

3.14.4 The Project Report/Thesis / Dissertation report / Drawings prepared according to approved guidelines and duly signed by the supervisor(s) and the Head of the Department shall be submitted to the concerned department.

3.14.5 The deadline for submission of final Project Report / Thesis / Dissertation is within 30 calendar days from the last working day of the semester in which Project / Thesis / Dissertation is done.

3.14.6 If a student fails to submit the Project Report / Thesis / Dissertation on or before the specified deadline he / she is deemed to have not completed the Project Work / Thesis / dissertation and shall re-register the same in a subsequent semester.

3.14.7 A student who has acquired the minimum number of total credits prescribed in the Curriculum for the award of Masters Degree will not be permitted to enroll for more courses to improve his/her cumulative grade point average (CGPA).

4.0 CLASS ADVISOR AND FACULTY ADVISOR

4.1 CLASS ADVISOR

A faculty member will be nominated by the HOD as Class Advisor for the whole class.

He/she is responsible for maintaining the academic, curricular and co-curricular records of all students throughout their period of study.

4.2 FACULTY ADVISOR

To help the students in planning their courses of study and for general counseling on the academic programme, the Head of the Department of the students will attach a certain number of 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 offer advice to the students on academic and personal matters, and guide the students in taking up courses for registration and enrolment every semester.

5.0 CLASS COMMITTEE

5.1 Every class of the PG Programme will have a Class Committee constituted by the Head of the Department as follows:

i. Teachers of all courses of the programme

ii. One senior faculty preferably not offering courses for the class, as Chairperson.

iii. Minimum two students of the class, nominated by the Head of the Department.

iv. Class Advisor / Faculty Advisor of the class - Ex-Officio Member

v. Professor in-charge of the PG Programme - Ex-Officio Member.

5.2 The Class Committee shall be constituted by the respective Head of the Department of the students.

5.3 The basic responsibilities of the Class Committee are to review periodically the progress of the classes to discuss problems concerning curriculum and syllabi and the conduct of classes. The type of assessment for the course will be decided by the teacher in consultation with the Class Committee and will be announced to the students at the beginning of the semester. Each Class Committee will communicate its recommendations to the Head of the Department and Dean (Academic Affairs). The class committee, without the student members, will also be responsible for finalization of the semester results and award of grades.

5.4 The Class Committee is required to meet at least thrice in a semester, first within a week of the commencement of the semester, second, after the first assessment and the third, after the semester-end examination to finalize the grades.

6.0 COURSE COMMITTEE

Each common theory course offered to more than one group of students shall have a “Course Committee” comprising all the teachers teaching 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 teaching the common course belong to a single department or to several departments. The Course Committee shall meet as often as possible and ensure uniform evaluation of the tests and arrive at a common scheme of evaluation for the tests. Wherever it is feasible, the Course Committee may also prepare a common question paper for the test(s).

7.0 REGISTRATION AND ENROLMENT

7.1 For the first semester every student has to register and enroll for all the courses.

7.2 For the subsequent semesters registration for the courses will be done by the student during a specified week before the semester-end examination of the previous semester. The curriculum gives details of the core and elective courses, project and seminar to be taken in different semester with the number of credits. The student should consult his/her Faculty Adviser for the choice of courses. The Registration form shall be filled in and signed by the student and the Faculty Adviser.

7.3 From the second semester onwards all students shall pay the prescribed fees and enroll on a specified day at the beginning of a semester.

7.4 A student will become eligible for enrolment only if he/she satisfies clause 9 and in addition he/she is not debarred from enrolment by a disciplinary action of the Institution. At the time of enrolment a student can drop a course registered earlier and also substitute it by another course for valid reasons with the consent of the Faculty Adviser. Late enrolment will be permitted on payment of a prescribed fine up to two weeks from the date of commencement of the semester.

7.5 Withdrawal from a course registered is permitted up to one week from the date of the completion of the first assessment test.

7.6 Change of a course within a period of 15 days from the commencement of the course, with the approval of Dean (Academic Affairs), on the recommendation of the HOD, is permitted.

7.7 Courses withdrawn will have to be taken when they are offered next if they belong to the list of core courses.

7.8 **A student should have registered for all preceding semesters before registering for a particular semester.**

8.0 TEMPORARY BREAK OF STUDY FROM THE PROGRAMME

A student may be permitted by the Dean (Academic Affairs) to avail temporary break of study from the programme up to a maximum of two semesters for reasons of ill health or other valid grounds. Such student has to rejoin only in the same semester from where he left. However the total duration for completion of the programme shall not exceed the prescribed maximum number of semesters (vide clause 3.1).

9.0 MINIMUM REQUIREMENTS TO REGISTER FOR PROJECT / THESIS / DISSERTATION

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. (Full time)	18 (III semester)
M.Tech. (Part time)	18 (V semester)
M.C.A. (Full time)	45 (V semester)
M.C.A. (Full time) – (Lateral Entry)	22 (V semester)
M.Sc.(Full time)	30 (IV semester) if project is in IV semester 18 (III semester) if project is in III semester

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 DISCIPLINE

10.1 Every student is required to observe discipline and decorous behavior both inside and outside the campus and not to indulge in any activity, which will tend to bring down the prestige of the Institution.

10.2 Any act of indiscipline of a student reported to the Head of the Institution will be referred to a Discipline and Welfare Committee for taking appropriate action.

10.3 Every student should have been certified by the HOD that his / her conduct and discipline have been satisfactory.

11.0 ATTENDANCE

11.1 Attendance rules for all Full Time Programme and Part time - day Time Programmes are given in the following sub-clause.

11.2 Ideally every student is expected to attend all classes and earn 100% attendance in the contact periods of every course, subject to a maximum relaxation of 25% for genuine reasons like on medical grounds, representing the University in approved events etc., 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. If the course is a core course, the student should register for and repeat the course when it is offered next. If the course is an elective, either he/she can register and repeat the same elective or can register for a new elective.

11.3 The students who have not attended a single hour in all courses in a semester and awarded 'I' grade are not permitted to write the examination and also not permitted move to next higher semester. Such students should repeat all the courses of the semester in the next Academic year.

12.0 SUMMER TERM COURSES

12.1 Summer term courses may be offered by a department on the recommendation of the Departmental Consultative Committee and approved by the Dean (Academic Affairs). No student should register for more than three courses during a summer term.

12.2 Summer term courses will be announced by the Head of the department at the end of the even semester before the commencement of the end semester examinations. A student will have to register within the time stipulated in the announcement. A student has to pay the fees as stipulated in the announcement.

12.3 The number of contact hours and the assessment procedure for any course during summer term will be the same as those during regular semesters.

Students with U grades will have the option either to write semester end arrears exam or to redo the courses during summer / regular semesters, if they wish to improve their continuous assessment marks subject to the approval of the Head of the department.

12.4 Withdrawal from a summer term course is not permitted. No substitute examination will be conducted for the summer term courses.

13.0 ASSESSMENTS AND EXAMINATIONS

13.1 The following rule shall apply to the full-time and part-time PG programmes (M.Tech./ M.C.A. / M.Sc.)

For lecture-based courses, normally a minimum of two assessments will be made during the semester. The assessments may be combination of tests and assignments. The assessment procedure as decided in the Class Committee will be announced to the students right from the beginning of the semester by the course teacher.

13.2 There shall be one examination of three hours duration, at the end of the semester, in each lecture based course.

13.3 The evaluation of the Project work will be based on the project report and a Viva-Voce Examination by a team consisting of the supervisor concerned, an Internal Examiner and External Examiner to be appointed by the Controller of Examinations.

13.4 At the end of industrial internship, the student shall submit a certificate from the organization and also a brief report. The evaluation will be made based on this report and a Viva-Voce Examination, conducted internally by a Departmental Committee constituted by the Head of the Department.

14.0 WEIGHTAGES

14.1 The following shall be the weightages for different courses:

(i) Lecture based course

Two continuous assessments	- 50%
Semester-end examination	- 50%

(ii) Laboratory based courses

Laboratory work assessment	- 75%
Semester-end examination	- 25%

(iii) Project work

Periodic reviews	- 50%
Evaluation of Project Report by External Examiner	- 20%
Viva-Voce Examination	- 30%

14.2 Appearing for semester end examination for each course (Theory and Practical) is mandatory and a student should secure a minimum of 40% marks in semester end examination for the successful completion of the course.

14.3 The markings for all tests, tutorial, assignments (if any), laboratory work and examinations will be on absolute basis. The final percentage of marks is calculated in each course as per the weightages given in clause 13.1.

15.0 SUBSTITUTE EXAMINATION

15.1 A student who has missed for genuine reasons any one of the three assessments including semester-end examination of a course may be permitted to write a substitute examination. However, permission to take up a substitute examination will be given under exceptional circumstances, such as accident or admissions to a hospital due to illness, etc.

15.2 A student who misses any assessment in a course shall apply in a prescribed form to the Dean (Academic Affairs) through the Head of the department within a week from the date of missed assessment. However the substitute tests and examination for a course will be conducted within two weeks after the last day of the semester-end examinations.

16.0 COURSEWISE GRADING OF STUDENTS AND LETTER GRADES

16.1 Based on the semester performance, each student is awarded a final letter grade at the end of the semester in each course. The letter grades and the corresponding grade points are as follows, but grading has to be relative grading

Letter grade	Grade points
S	10
A	9
B	8
C	7
D	6
E	5
U	0
W	-
I	-
AB	-

Flexible range grading system will be adopted

"W" denotes withdrawal from the course.

"I" denotes inadequate attendance and hence prevention from semester-end examination

"U" denotes unsuccessful performance in a course.

"AB" denotes absent for the semester end examination

16.2 A student is considered to have completed a course successfully if he / she secure five grade points or higher. A letter grade 'U' in any course implies unsuccessful performance in that course.

16.3 A course successfully completed cannot be repeated for any reason.

17.0 AWARD OF LETTER GRADE

17.1 A final meeting of the Class Committee without the student member(s) will be convened within ten days after the last day of the semester end examination. The letter grades to be awarded to the students for different courses will be finalized at the meeting.

17.2 After finalization of the grades at the class committee meeting the Chairman will forward the results to the Controller of Examinations, with copies to Head of the Department and Dean (Academic Affairs).

18.0 DECLARATION OF RESULTS

18.1 After finalization by the Class Committee as per clause 16.1 the Letter grades awarded to the students in the each course shall be announced on the departmental notice board after duly approved by the Controller of Examinations.

18.2 In case any student feels aggrieved about the results, he/she can apply for revaluation after paying the prescribed fee for the purpose, within one week from the announcement of results.

A committee will be constituted by the concerned Head of the Department comprising of the Chairperson of the concerned Class Committee (Convener), the teacher concerned and a teacher of the department who is knowledgeable in the concerned course. If the Committee finds that the case is genuine, it may jointly revalue the answer script and forward the revised marks to the Controller of Examinations with full justification for the revision, if any.

18.3 The “U” and “AB” grade once awarded stays in the grade sheet of the students and is not deleted when he/she completes the course successfully later. The grade acquired by the student later will be indicated in the grade sheet of the appropriate semester.

19.0 COURSE REPETITION AND ARREARS EXAMINATION

19.1 A student should register to re-do a core course wherein "I" or "W" grade is awarded. If the student is awarded "I" or "W" grade in an elective course either the same elective course may be repeated or a new elective course may be taken.

19.2 A student who is awarded "U" or "AB" grade in a course shall write the semester-end examination as arrear examination, at the end of the next semester, along with the regular examinations of next semester courses.

19.3 A student who is awarded "U" or "AB" grade in a course will have the option of either to write semester end arrear examination at the end of the subsequent semesters, or to redo the course whenever the course is offered. Marks earned during the redo period in the continuous assessment for the course, will be used for grading along with the marks earned in the end-semester (re-do) examination.

19.4 If any student obtained "U" or "AB" grade, the marks earned during the redo period for the continuous assessment for that course will be considered for further appearance as arrears.

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

20.0 GRADE SHEET

20.1 The grade sheet issued at the end of the semester to each student will contain the following:

(i) the credits for each course registered for that semester.

(ii) the performance in each course by the letter grade obtained.

(iii) the total credits earned in that semester.

(iv) the Grade Point Average (GPA) of all the courses registered for that semester and the Cumulative Grade Point Average (CGPA) of all the courses taken up to that semester.

20.2 The GPA will be calculated according to the formula

$$GPA = \frac{\sum_{i=1}^{n}(C_i)(GPi)}{\sum_{i=1}^{n}C_i} \qquad Where\ n = number\ of\ courses$$

where Ci is the number of credits assigned for i^{th} course

GP_i - Grade point obtained in the i^{th} course

For the cumulative grade point average (CGPA) a similar formula is used except that the sum is over all the courses taken in all the semesters completed up to the point of time.

'I' and 'W' grades will be excluded for GPA calculations.

'U', 'AB' 'I' and 'W' grades will be excluded for CGPA calculations.

20.3 Classification of the award of degree will be as follows:

CGPA	Classification
8.50 and above, having completed all courses in first appearance	First class with Distinction
6.50 and above, having completed within a period of 2 semesters beyond the programme period	First Class
All others	Second Class

However, to be eligible for First Class with Distinction, a student should not have obtained U or I grade in any course during his/her study and should have completed the PG Programme within a minimum period covered by the minimum duration (clause 3.1) plus authorized break of study, if any (clause 8). To be eligible for First Class, a student should have passed the examination in all courses within the specified minimum number of semesters reckoned from his/her commencement of study plus two semesters. For this purpose, the authorized break of study will not be counted. The students who do not satisfy the above two conditions will be classified as second class. For the purpose of classification, the CGPA will be rounded to two decimal places. For the purpose of comparison of performance of students and ranking, CGPA will be considered up to three decimal places.

21.0 ELIGIBILITY FOR THE AWARD OF THE MASTERS DEGREE

21.1 A student shall be declared to be eligible for the award of the Masters 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.

21.2 The award of the degree must be approved by the University.

22.0 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.

CURRICULUM & SYLLABI FOR M.Sc. MATERIALS SCIENCE

(FOUR SEMESTERS / FULL TIME)

CURRICULUM

SEMESTER I

Sl. No.	Course Code	Course Title	L	T	P	C
1.	PHB6102	Mathematical Physics	4	0	0	4
2.	PHB6121	Material characterization	3	0	0	3
3.	PHB6122	Electronics & Instrumentation	3	0	0	3
4.	PHB6123	Classical Mechanics and Statistical Thermodynamics	3	0	0	3
5.	PHB6124	Crystal growth techniques	3	0	0	3
6.	PHB6125	Properties of materials	4	0	0	4
7.	PHB6126	Materials Science Lab I	0	0	6	3
						23

SEMESTER II

Sl. No.	Course Code	Course Title	L	T	P	C
1.	PHB6231	Numerical Methods	3	0	0	3
2.	PHB6211	Quantum mechanics	4	0	0	4
3.	PHB6232	Photonic Materials and devices	3	0	0	3
4.	PHB6233	Physics of Materials	4	0	0	4
5.	PHB6234	Physical Metallurgy	3	0	0	3
6.		Elective-I	3	0	0	3
7.	PHB6235	Seminar				1
8.	PHB6236	Materials Science lab II	0	0	6	3
						24

SEMESTER III

Sl. No.	Course Code	Course Title	L	T	P	C
1.	PHB7121	Materials Testing Methods	3	0	0	3
2.	PHB7122	Ceramic Materials	3	0	0	3
3.	PHB7123	Polymeric Materials	3	0	0	3
4.	PHB7124	Composite Materials	3	0	0	3
5.	PHBY07	Nanoscience and Technology (compulsory elective II)	3	0	0	3
6	PHB7125	Project Work Phase –I				2*
7.	PHB7126	Materials Testing & Characterization lab	0	0	6	3
						18

SEMESTER IV

Sl. No.	Course Code	Course Title	L	T	P	C
1.		Elective -III	3	0	0	3
2.		Elective -IV	3	0	0	3
3.	PHB7221	Project Work Phase –II				6
						14

* 2 credits of Project work - Phase I will be accounted in the Phase II of the Project work

TOTAL CREDITS: 79

LIST OF ELECTIVE SUBJECTS

Sl. No.	Course Code	Course Title	L	T	P	C
1.	PHBY03	Thin film science and technology	3	0	0	3
2	PHBY07	Nanoscience and Technology	3	0	0	3
3	PHBY41	Materials processing	3	0	0	3
4.	PHBY42	Laser applications	3	0	0	3
5.	PHBY43	Electro-Optic materials and devices	3	0	0	3
6.	PHBY44	Corrosion science and technology	3	0	0	3
7.	PHBY45	Non-Destructive Testing	3	0	0	3
8.	PHBY46	Ferroelectric materials and devices	3	0	0	3
9.	PHBY47	High pressure science and technology	3	0	0	3
10.	PHBY48	Structure and properties of alloys	3	0	0	3
11.	PHBY49	Advanced materials	3	0	0	3
12.	PHBY50	Smart materials and structures	3	0	0	3
13.	PHBY51	Biomaterials	3	0	0	3
14.	PHBY52	Nuclear physics and reactor materials	3	0	0	3
15.	PHBY53	Ultrasonics and applications	3	0	0	3

SEMESTER I

PHB6102 MATHEMATICAL PHYSICS

L	T	P	C
4	0	0	4

OBJECTIVES:

- To understand the basic concepts in Mathematical Physics.
- To have an overall idea about the use of mathematical methods in physics.

MODULE I VECTORS AND TENSORS 12

Vector analysis: Gradient –Divergence –Curl-second order derivatives – Gauss's theorem- Stoke's theorem-Green's theorem – Curvilinear coordinates-spherical polar-cylindrical coordinates. 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.

MODULE II SECOND ORDER LINEAR DIFFERENTIAL EQUATIONS AND SPECIAL FUNCTIONS 12

Legendre, Bessel and Laguerre differential equations –series solutions-generating functions-recurrence relations- Stum- Liouvillie 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, VECTOR SPACES AND GREEN FUNCTIONS 12

Fourier Transform: Fourier transform – sine and cosine transform – properties Faultung's theorem- application in heat conduction and spectroscopy. Vector spaces: Definition –Linear dependence-Linear independence of vectors- 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 GROUP THEORY 12

Basic definitions – group – subgroups-classes- Isomorphism-Homomorphism – cosets- Normal subgroups-factor groups – point groups-space groups-The great orthogonality theorem- representations – MODULEary representations – character tables for C3v groups – rotation groups – 0(3), SU(2) & SU(3) groups.

Total Hours: 60

REFERENCES:

1. Gupta. B. D , Mathematical Physics - 3rd Revised Edition, Vikas Publishing House Pvt Limited, 2004.
2. Arfken. G and Weber.H. J Mathemattical Methods for Physicists, 4th ed. Physicists, Prism Books, Banagalore, 1995.
3. Chattopadhyay. P.K, Mathematical Physics, Wiley Eastern Ltd., New Delhi, 1990.
4. Joshi. A. W, Matrices and Tensors in Physics, Wiley Eastern Ltd., New Delhi 1975.
5. Murry R.Speigel, Theory and problems of complex variables, SI Metric edition, 1974.
6. Eugene Butkov, Mathematical Physics, Addison Wesley, London, 1973

OUTCOME:

At the end of the course, the students will be able to understand the basic concepts on Mathematical sciences.

PHB6121 MATERIAL CHARACTERIZATION

L	T	P	C
3	0	0	3

OBJECTIVES:

The students are trained in

- various spectroscopic techniques
- electron beam techniques
- XRD methods
- thermal analysis
- electrical methods

MODULE I X-RAY DIFFRACTION METHODS 9

Determination of Miller indices – Laue method - rotating crystal method, powder methods, debye sherer camera- Laue method, rotating crystal method, powder method, Debye-Scherrer camera. Intensity of diffracted beams, Scherrer formula to estimate the crystallite size.

MODULE II SPECTROSCOPIC TECHNIQUES 9

Fourier Transform Infrared Spectroscopy – Raman Spectroscopy– Photoluminescence – light-matter interaction – electroluminescence- Mass spectroscopy\sins-ICPMS-PIXE-RDX-EDAX- Proton induced X- ray emission spectroscopy (PIXE)- X-ray emission spectroscopy – X-ray photoelectron spectroscopy (XPS)-Ultraviolet photoelectron spectroscopy(UPS)-Auger electron spectroscopy (AES)- NMR-NQR-ESR.

MODULE III MICROSCOPIC TECHNIQUES 9

Optical microscopy techniques: Bright field optical microscopy – Dark field optical microscopy – Dispersion staining microscopy – phase contrast microscopy – differential interference contrast microscopy – fluorescence microscopy – confocal microscopy- scanning probe microscopy (STM, AFM) – scanning new field optical microscopy – digital holographic microscopy – Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Transmission electron microscopy (STEM)– Field Ion Microscopy (FIM)- Atom probe microscopy – Data collection, processing and analysis.

MODULE IV THERMO MECHANICAL TECHNIQUES 9

Thermo gravimetric analysis (TGA) – differential thermal analysis (DTA) – differential scanning calorimetry (DSC) – Dynamic mechanical analysis (DMA) – Thermo mechanical analysis (TMA) – Universal testing machine – impact strength – hardness.

MODULE V ELECTRICAL METHODS 9

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

Total Hours: 45

REFERENCES:

1. Stradling, R.A; Kilpstain, 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. Kealey D & P.J Haines, Analytical Chemistry , Viva Books Private Limited, New Delhi 2002.
5. Cullity B.D, “Elements of X-Ray Diffraction”, Addison Wesley publishing Co; 1967.

OUTCOMES:

The students will

- demonstrate the understanding of spectroscopic techniques
- demonstrate an understanding of electron beam techniques.
- demonstrate an understanding of XRD techniques.
- demonstrate the understanding of thermal methods
- demonstrate the understanding of electrical methods

PHB6122 ELECTRONICS AND INSTRUMENTATION

L	T	P	C
3	0	0	3

OBJECTIVE:

- To provide the knowledge on the construction of various electronic devices, circuits, optoelectronic devices and instrumentation.

MODULE I SEMICONDUCTOR DEVICES 9

Special diodes- Zener, LED, Photodiode, Schottky diode, Diac and Triac, Tunel diode – MOSFET, SCR, SCS, UJT, MIS diodes, Solar cells – phototransistors.

MODULE II ANALOG ELECTRONICS 9

Op-amp – introduction – op-amp based circuits - comparators and controls – mathematical operations – analog simulation - log and exponential amplifiers, oscillators using op-amp, 555 Timer circuits, instrumentation amplifiers – active filters – composite transistor circuits, BJT and FET oscillators, relaxation oscillators.

MODULE III DIGITAL ELECTRONICS 9

Introductory digital concepts – overview of logic functions and logic gates – combinational logic - flip-flops and related devices – registers, counters, shift registers and memory MODULEs - introduction to microprocessors- A/D and D/A conversion.

MODULE IV OPTOELECTRONICS 9

Semiconductor diode lasers – optical fiber and characteristics – modes of propagation – losses in fibres - fibre optic communication, optoelectronic modulation and switching devices – optocoupler – magnetic and optical data storage techniques.

MODULE V INSTRUMENTATION 9

Qualities of measurements – digital instruments – transducers, strain gauge, LVDT. load cell, piezo electric transducers, temperature transducers, flow meters - signal conditioning – data acquisition, conversion and transmission – digital signal processing.

Total Hours: 45

REFERENCES:

1. B.G. Stretman and S. Banerjee, 'Solid state electronic devices', (5^{th} Edition), Pearson Education Inc., New Delhi, (2000).
2. A.P. Malvino, 'Electronic principles', (6^{th} Edition), Tata McGraw Hill Publ.Co.Ltd., New Delhi (1999).
3. T.L.Floyd, Electronic Devices (6^{th} Edition), Pearson Education Inc., New Delhi, 2003
4. P.Bhattacharya, Semiconductor Optoelectronic Devices, 2^{nd} Edition, Pearson Education Inc., New Delhi, 2002.
5. H.S.Kalsi, Electronic Instrumentation, 2^{nd} Edition, Tata McGraw Hill Publishing Co., New Delhi 2004.
6. William David Cooper, Electronic Instrumentation and Measurement techniques – Prentice Hall of India Pvt. Ltd., 1991.
7. A.K.Sawhney, Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai and Sons, New Delhi, 1990.

OUTCOME:

At the end of the course, the students will be able to understand the construction of electronic devices, circuit, optoelectronics devices and instrumentations.

PHB6123 CLASSICAL MECHANICS AND STATISTICAL THERMODYNAMICS

L	T	P	C
3	0	0	3

OBJECTIVE:

- To provide the knowledge on classical theories of particle mechanics, thermo dynamical aspects and statistical functions.

MODULE I DYNAMICS 9

Virtual work - Generalised coordinates — d'Alembert's principle – Lagranges equation of motion – Cyclic co-ordinates and conservation laws - Euler Lagrange equation - Rutherford's scattering - Hamiltonian dynamics – Hamilton's equations of motion – Principle of least action – Canonical transformation – Poisson brackets.

MODULE II CHEMICAL POTENTIAL 9

Helmholtz and Gibbs free energies – Thermodynamic reactions – Euler equation – Maxwell's relations and applications – Gibbs phase rule – phase equilibria (single and multicomponent sysems - Clausius – Clayperon equation – law of mass action – first order phase transition in single component systems.

MODULE III ENSEMBLES 9

Microcanonical, canonical and grand canonical ensembles – Maxwell – Boltzmann, Bose- Einstein and Fermi-Dirac statistics – Comparison of MB, BE and FD statistics.

MODULE IV APPLICATION OF STATISTICS 9

Stefan-Boltzmann law – Einstein model of a solid – Bose condensation – Classical partition function and classical ideal gas – Equipartition theorem – Semiconductor statistics – Statistical equilibrium of free electrons in semiconductors.

MODULE V HEAT AND MASS TRANSFER 9

Basic concepts of conduction, convection and radiation – Fourier Law of Conduction - General Differential equation of Heat Conduction Types of Convection – Forced Convection – Dimensional Analysis Basic Concepts, Laws of Radiation – Stefan Boltzman Law, Kirchoffs Law –Black Body Radiation- Basic Concepts in mass transfer – Diffusion Mass Transfer.

Total Hours: 45

REFERENCES:

1. M.C.Gupta, Statistical Thermodynamics, Wiley Eastern Ltd., New Delhi, 1993
2. B.K.Agarwal and Melvin Eisner, Wiley Eastern Ltd., New Delhi –1988.
3. Herbert B.Callen, Thermodynamics, John Wiley and Sons, New York 1960.
4. H.Goldstein, Classical mechanics, Narosa Publising House, New Delhi, 1989.
5. Novak and R.Bialecki, Advanced Computational Methods in Heat Transfer, ISBN. 1853 (125911) 1998.
6. J.P.Holman,Heat transfer, Tata McGraw Hill,New Delhi, Ninth edition,2008.
7. Reif, F., Funamentals of Statistical and Thermal Physics, McGraw Hill, 1995. N.C. Rana, P.S.Joag-Classical Mechanics, Tata McGrawHill, New Delhi, 2008.

OUTCOME:

At the end of the course, the students will be able to understand the classical theories of particle mechanics, thermo dynamical aspects and statistical functions.

PHB6124 CRYSTAL GROWTH TECHNIQUES

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand and compare the various Crystal Growth techniques.
- To know the principle in the methods involved in the growth of crystal.

MODULE I THEORY OF CRYSTAL GROWTH 9

Nucleation – Different kinds of nucleation - Concept of formation of critical nucleus – Classical theory of nucleation - Spherical and cylindrical nucleus – Bulk crystal growth-BCF model-Tempkins model.

MODULE II SOLUTION GROWTH TECHNIQUE 9

Low temperature solution growth: Solution - Solubility and super solubility – Expression of super saturation – Miers T-C diagram –Induction period-nucleation rate- Slow cooling and solvent evaporation methods.

MODULE III GEL GROWTH TECHNIQUE 9

Principle – Various types – Structure of gel – Importance of gel – Experimental procedure –Chemical reaction method – Single and double diffusion method – Chemical reduction method – Complex and decomplexion method – Advantages of gel method.

MODULE IV MELT GROWTH TECHNIQUE 9

Bridgman technique - Basic process – Various crucibles design - Thermal consideration – Vertical Bridgman technique - Czochralski technique – Experimental arrangement – Growth process.

MODULE V VAPOUR GROWTH TECHNIQUE 9

Physical vapour deposition – Chemical vapour deposition (CVD) –Epitaxy-VPE-MOCVD-MBE- Chemical Vapour Transport – Plasma Chemical vapour deposition.

Total Hours: 45

REFERENCES:

1. Brice, J. C. Crystal Growth processes – Halstesd press, John Wiley & sons, New York (1986)
2. Elwell. D and Scheel. H. J, crystal growth from High Temperature solutions,Academic press, London (1975)
3. Buckley, H. E, ‘ Crystal Growth’ , Chapman and Hall, London(1952)
4. Heinz K. Henisch, Crystal Growth in Gels Dover publications (1996)
5. Mallin, J. N, ‘Crystallization’, Butternmths, London (2004)
6. Hand book of crystal growth, Volume 1, 2 & 3. Edited by D. T. J. Hurle North Holland – London (1993)
7. Ichiro Sunagawa, Crystal Growth, Morphology and performance, CambridgeUniversity press, (2005).
8. Hartman.P, Crystal growth and introduction, Amsterdam, London, American Elsevier,1973

OUTCOME:

At the end of the course, the students will be able to understand the various techniques involved in Crystal Growth.

PHB6125	PROPERTIES OF MATERIALS	L T P C
		4 0 0 4

OBJECTIVE:

- To impart knowledge on various properties of materials.

MODULE I MECHANICAL PROPERTIES 12

Factors affecting mechanical properties - mechanical tests - tensile, hardness, impact, creep and fatigue - elastic constants-analysis of elastic strains-Elastic compliance and stiffness constants- Plastic deformation - shear strength - work hardening and recovery - fracture – creep & creep resistant materials – fracture- Griffith's theory.

MODULE II DIELECTRIC AND RELATED PROPERTIES 12

Dielectric constant and polarizability - different kinds of polarization - Internal electric field in a dielectric -Clausius- Mossotti equation - dielectric in a AC field - dielectric loss - Ferroelectric and piezoelectric materials : classification of ferroelectric material – dipole theory of ferroelectricity-ferroelectric domains – ferroelectric transition- application - piezoelectric materials- application- pyroelectric materials.

MODULE III MAGNETIC PROPERTIES 12

Classification - dia, para, ferro, antiferro and ferrimagnetism – Bohr magneton- rare earth ions-Hund rules-Iron group irons-crystal field splitting - - ferromagnetism - domain theory - Weiss molecular field theory, Heisenberg's theory- exchange interaction - magnetic anisotropy - magnetic domains – domain walls - exchange energy- hysteresis - hard and soft magnetic materials- antiferromagnetism - two sublattice theory - ferrites – properties, structure and applications - magnetic bubbles - magnetoresistance - GMR materials - dilute magnetic semiconductor (DMS) materials (introduction)-magnetic resonance- EPR and NMR.

MODULE IV PROPETRIES OF SEMICONDUCTORS 12

Semiconductors – direct and indirect gaps – carrier statistics (intrinsic and extrinsic) – law of mass action and chemical potential of semiconductors – electrical conductivity and its temperature variation – (III – V) and (II – VI) compound semiconductors – excitons and polarons – LED- phosphors – Hall effect theory and experiment.

MODULE V PROPERTIES OF SUPERCONDUCTORS 12

Superconductivity – critical parameters – anomalous characteristics – isotope effect, Meissner effect – type I and II superconductors - BCS theory (elementary) – London equation- coherence length-Josephson junction and tunneling – SQUID - High temperature superconductors - applications.

Total Hours: 60

REFERENCES:

1. V.Raghavan, Materials Science and Engineering, Prentice Hall, 2003.
2. Charles Kittel, Introduction to solid state physics, Wiley 7th edition, 1996.
3. K.V.Keer, 'Principles of solid state physics', Wiley - Eastern, 1993.
4. N.W. Ashcroft and N.D. Mermin , 'Solid state Physics', Saunders 1976.
5. D.R.Tilley and J.Tilley, Superfludity and superconductivity, 3rd Edition, Hilger,1990.
6. Lawrence H.Van Vlack, Elements of Materials Science and Engineering, Sixth Edition, 1998.

OUTCOME:

At the end of the course, the student will be able to understand the mechanical, dielectric, magnetic, semiconducting and superconducting properties of materials and their applications to technology.

PHB6126 MATERIALS SCIENCE LABORATORY – I

L	T	P	C
0	0	6	3

LIST OF EXPERIMENTS:

1. Electrical conductivity of metals and alloys with temperature-four probe method
2. Hall effect
3. Magnetic susceptibility-Quincke's method
4. Crystal Growth-Solution technique
5. Ultrasonic interferometer – ultrasonic velocity in liquids
6. Ferroelectricity – Hysteresis loss
7. Arc spectrum – Identification of elements
8. Fraunhofer diffraction - using laser
9. Band gap determination
10. Feedback Amplifier
11. Monostable, Astable and bistable Multivibrator using transistors
12. Phase shift Oscillator
13. Wienbridge Oscillator
14. Characteristics of MOSFET
15. Characterisitics of UJT
16. Operational Amplifier
17. Dual Power Supply- construction
18. Half Adder, Hall- Subtractor, Full Adder and Full- Subtractor
19. 4-bit parallel Binary Adder.

SEMESTER - II

PHB6231 NUMERICAL METHODS

L	T	P	C
3	0	0	3

OBJECTIVE

- To impart the knowledge on a systems of equations, probability statistics, error analysis and programming concepts.

MODULE I SYSTEM OF EQUATIONS : INTERPOLATION AND CURVE FITTING 9

Roots of equations - Methods of bisection and false position - Newton-Raphson method - Solution of simultaneous linear algebraic equations - Gauss elimination - Eigenvalues of Matrices-Power method and Jacobi's method-Newton's forward and backward interpolation formulae - Lagrange's method - Lagrange's inverse interpolation - curve fitting - principle of least squares.

MODULE II NUMERICAL DIFFERENTIATION AND INTEGRATION 9

Newton's forward and backward difference formulae - numerical integration - Trapezoidal rule and Simpson's rule - numerical solution of ordinary differential equations - Taylor series - Euler's method, improved and modified methods - Runge- Kutta methods - Milne's predictor -corrector method- Testing Goodness of fit - Error analysis – Accuracy and precision –Significant figures.

MODULE III C-PROGRAMMING 9

Structure – pointers – types of variables-arrays-functions (intrinsic and user defined) – arithmetic operations and shorthand notations – loops (do, for, if loops) – elementary examples of programs (three programs at least from each of the above MODULES).

MODULE IV BASICS OF COMPUTATIONAL PHYSICS 9

Central field approximation – Hamiltonian of the solid – Born - Openheimer approximation – Thomas Fermi model – LCAO –The Hartree approximation – Variational principle - Hartree – Fock approximation- The total energy according to band theory.

MODULE V DENSITY FUNCTINAL THEORY 9

Density functional theory (Kohn-Sham equation) - Exchange correlation potential VXC schemes- Local density approximation- Introduction to methods for calculations of energy bands and their features .

Total Hours: 45

REFERENCES:

1. M.K.Venkatraman, "Numerical Methods in Science and Engineering", National Publishing Company, Madras, 1996
2. S.S.Sastry, "Introductory Methods of Numerical Analysis", Prentice Hall of India, New Delhi, 1992.
3. Walpole .E, Myers,R.M, Myers, S.L and Ye,K, “Probability & Statistics for Engineers and Scientists”, Pearson Education, 2002.
4. B.S.Grewal, Numerical Methods in Engineering and Science, Khanna Publishers, New Delhi, 2006.
5. Dey, P and Ghosh, M, “ Programming in C”, Oxford University Press, 2007.

OUTCOME:

At the end of the course the students will be able to understand the basic concepts of numerical methods and programming.

PHB6211 QUANTUM MECHANICS L T P C
4 0 0 4

OBJECTIVES:

- To study the basic concepts of quantum mechanics.
- To understand the different approximation methods used in quantum mechanics.

MODULE I QUANTUM BASICS 12

Schrodinger time independent and dependent equations- solution of free particle (1 Dimensional)- arbitrary potential – physical Interpretation of Ψ - Normalization – Conservation of probability – expectation values:Ehrenfest theorem-Basic postulates -Operators : Definition and properties- Eigen values and Eigen functions - self adjoint operators – Parity operator- uncertainty principle. (Statement and Proof).

MODULE II EXACTLY SOLVABLE SYSTEMS 12

One dimensional linear harmonic oscillator – solutions to a square well potential – spherically symmetric potential and schrodinger equation- Rigid rotator : eigen values and radial wave function – hydrogen atom: energy eigen values and complete wave function (Ψ 100).

MODULE III APPROXIMATION METHODS 12

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

MODULE IV EQUATION OF MOTION AND ANGULAR MOMENTUM 12

Quantum pictures : Schrodinger, Heisenberg and Interaction – Angular momentum operator- Commutation rules – the eigen value spectum – raising and lowering operators- C.G coefficients (no properties of C.G coefficients)- C.G coefficients when $J_1=J_2=1/2$.

MODULE V RELATIVISTIC QUANTUM MECHANICS 12

K.G. equation – charge and current densities – Dirac's equation – Dirac matrices- properties spinors – spin of Dirac's particle- Zitterbewegung – Negative energy states- spin magnetic moment.

Total Hours: 60

REFERENCES:

1. P.M.Mathews and Venkatesan, A text book of quantum mechanics, Tata McGraw Hill.
2. S.L.Kakani and Chandyla, Quantum mechanics: Theory and Problems- (IVth Edition)
3. Schiff, Quantum mechanics, Mc Graw Hill, 1968
4. E.Merzbacker, Quantum mechanics, Wiley Publishers , 3rd Edition 1988
5. Bjorkan. J.D. Drell. S, Relativistic Quantum Mechanics, McGraw Hill Publications, 1965.

OUTCOMES:

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

- basics of quantum mechanics.
- various physics concepts in the light of quantum mechanics.

PHB6232 PHOTONIC MATERIALS AND DEVICES

L	T	P	C
3	0	0	3

OBJECTIVE:

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

MODULE I SEMICONDUCTOR PHYSICS 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-confined 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

Photodiodes: current-voltage equation – operation-spectral response of Ge and Si – quantum efficiency – response time – diffusion time – drift – capacitance of diodes, measurement - device configuration and efficiency – device performance.

MODULE V INSTRUMENTATION 8

Measurements using lenses, monochromators, spectrometers, grating, mirrors, lock-in amplifiers – characterization of photodiodes, LEDs and laser diodes – modulation of lasers – rate equations.

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.

OUTCOMES:

At the end of the course, the students would be able

- to understand the properties of a photonic materials.
- to fabricate photonic devices and its characterization techniques.

PHB6233	PHYSICS OF MATERIALS	L T P C
		4 0 0 4

OBJECTIVE:

- To provide the knowledge of the theoretical concepts of Physics of Materials

MODULE I CRYSTAL STRUCTURE 12

Crystalline solids – basis and crystal structure- Wigner-Seitz primitive cell - Bravais lattices - crystal systems – coordination number – packing factor – cubic, hexagonal, diamond structures – lattice planes – Miller indices – interplanar distances – crystal directions - orientation of planes in crystal, concept of reciprocal lattice -. Symmetry : Point group and Space group - Diffraction of X-rays by crystal – Laue conditions- line intensities -Elementary concepts of polycrystalline, nanocrystalline and amorphous materials - Crystal defects.

MODULE II BONDING PROPERTIES 12

Nature of bonding - atomic orbitals - concept of localized covalent bond, molecular orbital, hybridization- bond angles, bond lengths, bond order and bond energies – electronegativity - partial ionic character of covalent bond - dipole moments and inductive effect- Ionic bond: properties of ionic compounds, ionic radii, factors affecting ionic radii, radius ratio, types and structures of simple ionic compounds, lattice energy, Born Lande equation, Born-Haber cycle- cohesive energy -applications, size effects, polarizing power and polarizability of ions, covalent characteristics in ionic compounds.

MODULE III ELECTRONS IN SOLIDS 12

Fermi Dirac distribution - density of states - electronic specific heat. - Boltzmann transport equation - Sommerfeld' theory of electrical conductivity.- Band theory of solids – nearly free electron approximation- origin of gap-Block theorem - Kronig Penny model.- wave equation of electron in periodic potential- effective mass of electron and concept of hole- Brillouin zones and boundaries – Fermi surface-band model for metals, semiconductors and insulators - semimetals.

MODULE IV BAND STRUCTURE THEORY OF SOLIDS 12

Central field approximation – Hamiltonian of the solid – Born - Openheimer approximation – Thomas Fermi model – LCAO –The Hartree approximation – Variational principle - Hartree – Fock approximation- The total energy according to band theory- Density functional theory (kohn-sham equation) - Exchange correlation potential VXC schemes- Local density approximation- Introduction to methods for calculations of energy bands and their features.

MODULE V PHONONS IN SOLIDS 12

Vibration of crystals in monatomic basis - vibration of crystals in diatomic lattices – quantization of elastic waves - phonon momentum-inelastic scattering by phonons - Thermal properties – phonon heat capacity - density of states – Einstein theory of lattice energy - Debye theory of lattice energy-phonon dispersion curves – anharmonic crystal interactions - thermal expansion - thermal conductivity - Umklapp processes.

Total Hours: 60

REFERENCES:

1. N.W. Ashcroft and N.D. Mermin Solid State Physics, Thomson Brrooks/Cole (1976)
2. C.Kittel, Introduction to Solid State Physics 7th Ed.
3. Harald Ibach and Hans Lueth, Solid State Physics, 2nd edition Springer (1996)
4. H.P.Myers, Introductory Solid State Physics, 2nd edition, Viva Books Pvt. Ltd (1998)
5. M.Ali Omar, Elementary Solid State Physics, revised printing Pearson Education (2000)
6. M.S. Rogalski and S.B. Palmer, Solid Statae Physics, Gordon Breach Science Publishers (2000)
7. A.J Dekker, Solid State Physics, Prentice Hall (1957).
8. G.C.Fletcher ‘Electron theory of solids’, North Holland Pub. Co., 1980.
9. Raimes, “ The wave mechanics of electrons in metals” , North Holland, 1967.
10. Efthimios Kaxiras, “Atomic and Electronic structure of solids”, Cambridge Press.

OUTCOME:

At the end of the course, the student will be able to understand the different crystal structures, crystal symmetry, bonding nature, band theory of solids, methods to investigate the band structure of solids and phonon in solids leading to thermal properties

PHB6234 PHYSICAL METALLURGY

	L	**T**	**P**	**C**
	3	**0**	**0**	**3**

OBJECTIVE:

- To expose with topics related to phase diagrams, alloys, heat treatment methods and phase transformations.

MODULE I PHASE DIAGRAMS 9

Composition and classification of pig iron and cast iron – iron ores - manufacture of wrought iron and steel The phase rule – binary equilibrium diagrams – invariant reactions- eutectic, eutectoid, peritectic and pertectoid reactions – free energy composition curves – micro structural changes during cooling – metallurgical microscope, grain size analysis, grain size measurement - effect of grain size on properties of metals and alloys

MODULE II SOLID SOLUTION 9

Types of solid solution – solid solution factors governing substitutional solubility –Hume-Rothery rules- intermediate phases -solid solution alloys –Vegards law – Lever rule - mechanical mixtures- - Iron-Carbon equilibrium diagram – Aluminum alloys – Copper alloys – Effect of alloying elements – Experimental determination of equilibrium diagram.

MODULE III HEAT TREATMENT 9

Cold working and hot working - Recovery, recrystallisation and grain growth.T-T-T diagrams – C-C-T diagrams – heat-treatment processes – annealing, normalising, quenching and tempering – baths used in heat treatment – hardenability – Jominy's end quench test – martempering and austempering – case hardening – induction, flame, laser - carburising, cyaniding, nitriding, carbo nitriding.

MODULE IV PHASE TRANSFORMATIONS 9

Types of phase changes – diffusion in solids – Nucleation and growth – solidification – pearlitic transformations – martensitic transformations – kinetics of transformation -precipitation and age hardening.

MODULE V ENGINEERING ALLOYS 9

Low carbon steels – mild steels – high strength structural steels – tool materials – stainless steels – super alloys – light alloys – shape memory alloys – applications.

Total Hours: 45

REFERENCES:

1. V.Raghavan, Physical metallurgy, Prentice-Hall of India, New Delhi, 1983
2. A.G.Guy and J.Hren, Elements of Physical Metallurgy, Oxford University Press, 1984.
3. S.H.Avener, Physical Metallurgy, Mc Graw Hill, 1974
4. Robert.E.Reed-Hill, Physical Metallurgy Principles, D.Van Norstrand Inc., 1964
5. I.S.Polmear, Light Alloys, Third Edition, Metallurgy and Materials Science, 1995
6. William F.Smith, Structural Properties of Engineering Alloys, Mc Graw Hill Publications, 1993.
7. R.K.Rajput, Materials Science and Engineering, S.K.Kataria & Sons, New Delhi, 2002.

OUTCOME:

At the end of the course students will be able to understand phase diagrams, alloys, heat treatment methods and phase transformations.

PHB6236 MATERIALS SCIENCE LABORATORY – II

L	T	P	C
0	0	6	3

LIST OF EXPERIMENTS:

1. Determination of elastic constants – Hyperbolic fringes
2. Determination of elastic constants – Elliptical fringes
3. Determination of dielectric constant
4. Magnetostriction measurements
5. Study of crystal lattices
6. Conductivity of ionic crystals
7. Dielectric constant of a non-polar liquid.
8. Diploe moment of an organic molecule
9. Verification of a curie wein law for a ferro electric materials –Temperature dependence of a ceramic capacitor.
10. Real & imaginary concept of dielectric materials
11. Tracing the BH loop of a soft & hard magnetic materials.
12. NDT – ultrasonic flaw detector
13. Liquid penetrent inspection
14. Band structure and band gap determination
15. Density of states -calulation
16. Magnetic properties determination.
17. Mat lab 4 experiments.

SEMESTER - III

PHB7121 MATERIALS TESTING METHODS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To introduce the standard procedures and methods of testing of materials.
- To impart knowledge of various methods adopted for testing of mechanical, electrical, optical and magnetic properties of materials.

MODULE I STANDARDS OF TESTING METHODS 7

Global standards and specifications and their importance with reference to metals, plastics, rubbers and composites. Preparation of test specimen by various techniques for ferrous and non- ferrous metals, thermoplastics, thermo sets, elastomers and composites. Conditioning of specimens and test atmospheres.

MODULE II MECHANICAL PROPERTIES 9

Tensile, compression, flexural, shear, tear, impact, abrasion, hardness, permanent set, resilience, flex and cut growth resistance. Creep and stress relaxation, fatigue.

MODULE III THERMAL PROPERTIES 7

Transition temperatures, Vicat softening temperature, heat distortion temperature, coefficient of expansion, specific heat, thermal conductivity, shrinkage, brittleness temperature, and flammability.

MODULE IV ELECTRICAL PROPERTIES 8

Electrical conductivity - Volume and surface resistivity, dielectric constant and power factor, dielectric strength, arc resistance, tracking resistance, static charge Refractive index, light transmission, transparency, haze, gloss clarity, and birefringence.

MODULE V CHEMICAL AND ENVIRONMENTAL PROPERTIES 7

Corrosion resistance and chemical resistance of metals. Environmental stress crack resistance, water absorption, weathering and chemical resistance, aging, ozone resistance, permeability of plastics, rubbers and composites.

MODULE VI NON-DESTRUCTIVE TESTING 7

X-ray and ultrasonic testing, magnetic particle inspection, liquid penetrating testing. Ultra sonic testing, Radiography testing, Eddy current testing.

Total Hours: 45

REFERENCES:

1. Wole Soboyejo, 'Mechanical Properties of Engineered Materials' Marcel Dekker, 2002.
2. Vishu Shah, 'Handbook of Plastics Testing Technology', John Wiley, NY, 1998.
3. Roger.P.Brown, 'Hand Book of Polymer Testing', Marcel Dekker inc, New York, 1999.
4. Nicholas.P, Cheremisinoff, Paul N. Cheremisinoff, 'Handbook of Advanced Material Testing' Marcel Dekker, Inc. 1995.
5. ASTM Handbook Series,2004,

OUTCOMES:

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

- standard procedures and methods of testing of materials.
- various methods adopted for testing of mechanical, electrical, optical and magnetic properties of materials.

PHB7122 CERAMIC MATERIALS L T P C
3 0 0 3

OBJECTIVES:

Students are trained to be acquainted with

- fundamentals of ceramics
- different types of ceramic processing
- properties of ceramics
- types of ceramic materials
- applications of ceramics

MODULE I INTRODUCTION TO CERAMICS AND REFRACTORIES 9

Fundamentals of refractory science and engineering – gap grading, continuous grading – fabrication and firing – importance of phase diagram in Refractory- structure of ceramic crystal – Pauling's rules – oxide structures, silicate structures, clay minerals, polymorphism, displacive transformations, reconstructive transformation.

MODULE II PROPERTIES OF CERAMICS 9

Chemical properties: Corrosion and its prevention – galvanic theory, Half cell potentials, electrochemical corrosion, methods of corrosion prevention; Oxidation of metals, pilling – bed worth ratio, oxidation kinetics – Thermal properties: Heat capacity, thermal expansion of crystals, glasses and composite bodies – thermal conduction process – phonon conductivity: single phase and multiphase ceramics and glasses – Mechanical Properties: Modulus of elasticity of 2-phase and porous ceramics – Griffith's theory – abrasives-Knoop's scale – ceramic cutting tools – cermets – Electrical properties: Conductivity of ceramic materials – seebeck, Peltier and Thomson effects.

MODULE III CERAMIC PROCESSING 9

Powder Processing : Concept of mono-size and mono-dispersed submicron ceramic powder, powder preparation of high performance ceramics, powders from chemical solutions, powders from vapor phase reactions – co-precipitation- sol-gel techniques – spray drying, freeze drying-CVD – SHS -milling techniques- Forming methods: Hot pressing, Isostatic pressing, Injection molding, slip casting, tape casting, gel casting, doctor blade processing, coating processing, plasma processing, plasma synthesis- Sintering techniques : solid state sintering, local driving force for sintering, atomic mechanisms occurring during the sintering,

MODULE IV ENGINEERING CERAMICS 9

Ceramic Insulators : Porcelain insulators – triaxial, stealite, non feldspathetic types – composition, properties and uses – Ferroelectric ceramics: Classification of ferroelectric materials – properties of ferroelectric ceramics – hysteresis loop – PZT – PLZT materials, processing and fabrication – Magnetic ceramics: Classification of magnetic materials – domain theory – ferromagnetism – types of ferrites - Spinel ferrites, manganese ferrites, zinc ferrites, hexagonal ferrites, garnets - processing, and fabrication techniques - GMR – Structural Ceramics: Classification of Structural Ceramics – Carbides: Boron Carbide, Silicon Carbide, Nitrides: Boron, silicon and aluminium nitrides – Glass Ceramics: glass composition– Glass forming process, heat treatment, crystal nucleation in glass, nucleation agent – high purity silica glass, laser glasses, fiber glasses, optical glasses, non-oxide glasses

MODULE V APPLICATIONS OF CERAMICS 9

Ceramics for advanced applications: high temperature applications – silica refractories – alumina, mullite, carbide based refractories, cordierite, zirconia, fusion cast refractories, ceramic fibers. Nuclear Energy, magneto – hydrodynamic generation, gas turbine blades, abrasives, aerospace, diesel engines, heat exchangers, cutting tools, wear applications – Ceramics for medical applications: Tissue attachment mechanism, bioactive materials, porous ceramics, bioactive glass, calcium phosphate ceramics, implant materials, ceramics for dental applications – Ceramics for optical applications: CRT and TV picture tubes, telecommunication and related uses, information display, laser, fiber optics, electromagnetic windows – Ceramics in electrochemical cells: Sodium sulphate cell (with ß-alumina), electrical ceramics for fuel cell and high energy batteries.

Total Hours: 45

REFERENCES:

1. Richerson, D.W., Modern Ceramic Engineering: properties, processing and Use in design, Marcel Dekker Inc, New york, 1992.
2. Reed, J.S., Principles of Ceramic Processing, John Wiley &
3. Willam. F. Smith, “Foundations of Material Science & Engg”. Mcgraw Hill, Book Co: 2000.
4. Michael W. Barsoum “Fundamentals of Ceramics”, Mcgraw Hill, Book co. 1997.
5. Kingery, “Introduction to ceramics” John wiley publication, 1991.
6. Kwanchidao, “Dielectric phenomena in solids”, Elsevier Academic Press, 2004.
7. Charles A, Schacht, “Refractronic Hand book” Marcel Dekker, Inc; 2004.

OUTCOMES:

The students will:

- demonstrate the understanding of fundamentals of ceramics
- analyse and demonstrate the various types of ceramic processing
- illustrate the different types of ceramic matersials.
- learn the properties of ceramics.
- learn about the various applications of ceramics.

PHB7123 | **POLYMERIC MATERIALS** | **L T P C**
3 0 0 3

OBJECTIVES:

- To impart basic knowledge in the preparation, properties and applications of polymeric materials.
- To provide understanding for the selection of polymeric materials for engineering applications.

MODULE I INTRODUCTION 7

Basic concepts of polymers– classification and nomenclature. Polymerization reactions – addition, condensation and coordination polymerization. Techniques of polymerization- bulk, solution, suspension and emulsion polymerization.

MODULE II STRUCTURE AND PROPERTIES 7

Structure and property relationship- polymer molecular weight - transition and melting temperature- mechanical, thermal, electrical, chemical and environmental properties.

MODULE III COMMODITY THERMOPLASTICS 7

Structure, properties and applications of polyethylene (LDPE, HDPE, HMWPE) –polypropylene-polyvinyl chloride- polymethyl methacrylate,-polystyrene.

MODULE IV ENGINEERING THERMOPLASTICS 8

Structure, properties and applications of nylons – aromatic polyamides – polyesters- polyacetal- polycarbonate- polyurethanes - SAN-ABS.

MODULE V HIGH PERFORMANCE PLASTICS 8

Properties and applications of- polytetrafluoroethylene- polychlorofluoroethylene – polysulphid - PPO- polysulphone- polyether slphone-PEEK- polyimides.

MODULE VI THERMOSETS AND RUBBERS 8

Structure, properties and applications of unsaturated polyester resin – epoxy resin- silicone resin- phenolic resins-natural rubber-styrene butadiene rubber – butyl rubber- nitryl rubber- chloroprene rubber – EPDM- silicone rubber-fluorocarbon rubbers- polyurethane rubber.

Total Hours: 45

REFERENCES:

1. Irvin.I, Rubin,“ Hand book of plastic materials and technology’, Wilsey Interscience , NY,1990
2. Charles A Harper ‘ Handbook of Plastic, Elastomers, and composite’,4^{th} edition McGraw Hill Professional, 2002.
3. Joel R. Fried, Polymer science and Technology, Prentice Hall, NJ, 1995.
4. F.W. Billmeyer, Textbook of Polymer Science, Wiley international publishers, 1984.
5 D.W. Van Krevelen And P.J. Hoftyzen, "Properties of Polymer, 3^{rd} Edition, Elsevier Scientific Publishing Company, Amsterdam - Oxford – New York. 1990.
6. Manas Chanda and Salil K. Roy, Plastics Technology Handbook, Marcel Dekker, New York.
7. J.A.Brydson, “Plastics Materials”, Butterworth- Heinemann – Oxford, 6^{th} Ed., 1995.
8. Rubber Materials and their compounds – J.A.Brydson, Elsivier Applied Science, 1988.

OUTCOMES:

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

- the preparation, properties and applications of polymeric materials.
- the selection of polymeric materials for engineering applications.

PHB7124	COMPOSITE MATERIALS	L T P C
		3 0 0 3

OBJECTIVES:

- To impart basic knowledge of composite materials, processing and applications.
- To teach various techniques employed for the fabrication of composite products.
- To provide understanding of selection of composite materials for specific applications.

MODULE I INTRODUCTION 7

Classification- metal matrix – ceramic matrix – polymer matrix- carbon matrix composites.Constituents and their functions –particulate and fibrous reinforcements – matrix materials.Fibrous reinforcements – glass – carbon – aramids- metal oxide fibres. Matrix- whiskers - fibre interface.

MODULE II METAL MATRIX COMPOSITES 7

Metal Matrices - Reinforcements – particles – fibres. Effect of reinforcement - volume fraction – rule of mixtures. Processing of MMC – powder metallurgy process – diffusion bonding diffusion bonding-stir casting – squeeze casting. Characteristics of metal matrix composites, advantages and limitations.

MODULE III CERAMIC MATRIX COMPOSITES 7

Ceramic matrices - oxide ceramics – non oxide ceramics – aluminium oxide – silicon nitride – reinforcements – particles- fibres- whiskers. Processing - Sintering - Hot pressing – cold isostatic pressing – hot isostatic pressing. Properties, advantages and limitations.

MODULE IV 10

Polymeric resins – thermoplastics and trhermoset resins – reinforcement fibres – form of fibre reinforcement. Processing - hand layup processes – spray up processes – compression moulding – reinforced reaction injection moulding - resin transfer moulding – pultrusion – filament winding – injection moulding. Fibre reinforced plastics (FRP), Glass fibre reinforced plastics (GRP). Mechanical, thermal and electrical properties.

MODULE V POLYMER NANOCOMPOSITES 8

Nanoparticle fillers - carbon nanotubes- Inorganic fillers –polymer- filler interfaces-Modification of interfaces. Processing of polymer nanocomposites- direct mixing, melt mixing, solution mixing, in-situ polymerization, in-situ particle processing. Ceramic /polymer nanoomposites- metal /polymer nanocomposites. Characteristics properties and applications.

MODULE VI APPLICATIONS OF COMPOSITES 6

Applications of composites-aerospace, transport, marine, structural, chemical and corrosion resistant products, sports, electrical, electronics, communication and biomedical applications.

Total Hours: 45

REFERENCES:

1. S.T.Peter, 'Hand Book of Composites', Chapman and Hall, 1998.
2. P.K. Mallick, 'Composites Engineering Handbook' Marcel Dekker Inc.NY.,1997..
3. K. Srinivasan, 'Composite Materials: Production, Properties, Testing and Applications' Alpha Science International Ltd., 2008.
4. A.Brent Strong, 'Fundamentals of Composites Manufacturing: Materials, Methods and Applications', Second Edition, Society of Manufacturing Engineers, 2007.
5. A. K. Haghi, 'Composites and Nanocomposites' Apple Academic Press, 2013.
6. D.Hull and T.W.Clyne, "An introduction to Composite Materials" 2nd Ed., Cambridge,1996.
7. F.L. Matthews and R.D. Rawlings, 'Composite materials: engineering and science', Chapman and Hall, 1994.
8. Y.C.Ke,P.stroeve and F.S.Wang 'Polymer Layered Silicate and silica nanocomposites, Elesvier, 2005.
9. P.M. Ajayan, L.S. Schadler, P.V. Braun, 'Nanocomposite Science and Technology', WILEY-VCH Verlag GmbH, 2003.

OUTCOMES:

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

- composite materials, processing and applications.
- various techniques employed for the fabrication of composite products.
- selection of composite materials for specific applications.

PHB7126 MATERIALS TESTING & CHARACTERIZATION LAB

L	T	P	C
0	0	6	3

LIST OF EXPERIMENTS FOR MATERIALS CHARACTERIZATION LAB

1. Synthesis/Preparation of materials by different techniques

   (i) Polymer synthesis (ii) nanomaterial (iii) photonic materials

2. Characterization of materials by XRD,UV-Vis,IR, TGA/DTA, DSC.
3. Morphology of materials by SEM, TEM and AFM.

LIST OF EXPERIMENTS FOR MATERIALS TESTING LAB

TESTING OF MECHANICAL PROPERTIES OF METALS, PLASTICS, RUBBERS AND COMPOPSITES

1. Tensile strength
2. Compression strength
3. Flexural strength
4. Impact strength
5. Hardness

TESTING OF THERMAL PROPERTIES

1. Thermal Conductivity
2. Coefficient of Thermal Expansion
3. Heat distortion temperature
4. Thermal ageing resistance

TESTING OF ELECTRICAL PROPERTIES

1. Electrical conductivity
2. Electrical resistivity
3. Dielectric strength
4. Dielectric constant

TESTING OF MISCELLANEOUS PROPERTIES

1. Environmental resistance
2. Chemical resistance
3. Flammability

ELECTIVES

PHBY03 THIN FILM SCIENCE AND TECHNOLOGY **L T P C**
3 0 0 3

OBJECTIVES:

- To provide knowledge about the production and measurement of vacuum and working principles of vacuum coating MODULE
- To learn the concepts of Physics of thin films and various fabrication techniques of thin films for applications

MODULE I HIGH VACUUM PRODUCTION AND MEASUREMENTS 9

Vacuum production – rotary pump – diffusion pump – molecular pump – Turbo molecular pump - degassing - measurement of vacuum and MODULEs – types of gauges – Pirani gauge – Penning gauge – vacuum ranges of gauges - thin film vacuum coating MODULE- diffusion pump vacuum systems - turbo pump vaccum system- role of inert gases

MODULE II PHYSICS OF THIN FILMS 9

Low dimensional solids – electronic energy states in confined system – electron confinement quantum dots- electron confinement - electron confinement quantum wells and quantum wire – electron confinement -size dependence of physical properties - thin film growth methods- Atom by atom deposition – Growth laws – VW, FV and SK modes – thermodynamics-nucleation theory.

MODULE III PREPARATION METHODS - PVD 9

Physical Vapour Deposition methods (PVD): thermal evaporation method – sputtering-Study of glow Discharge -DC sputtering mechanism, RF sputtering, Pulsed Laser Deposition method - electron beam processing- Ion beam assisted deposition -merits and demerits of all these methods

MODULE IV PREPARATION METHODS - CHEMICAL METHODS 9

Chemical Vapour Deposition (CVD) - Atmospheric pressure CVD – MOCVD and PECVD processes - Chemical bath deposition method, dip coating method, photochemical method, spin coating method, spray pyrolysis, electroplating – differences between PVD and CVD - Thickness measurement-Multiple beam interference - quartz crystal – profilometer- ellipsometric - stylus techniques

MODULE V APPLICATIONS 9

Thin film capacitors: Materials - Capacitor structures - Thin film field effect transistors: Fabrication and characteristics - Thin film solar cells – antireflection coatings - interference filters - electrophotography- electrical and dielectric behaviour of thin films - components - strain gauges and gas sensors. Anisotropy in magnetic films - domains in films - computer memories - superconducting thin films – SQUID.

Total Hours: 45

REFERENCES:

1. Milton Ohring, The Materials Science of Thin Films, Academic Press, 2001.
2. C.C. Koch, 'Nano structured materials', Vol. 2, 1993.
3. A. Roth, 'Vacuum technology', North – Holand Pub., II Edition, 1982.
4. C.N.R. Rao, A. Muller, A. K. Cheetham (Eds.), 'The Chemistry of nanomaterials: synthesis, properties and applications', WILEY-VCH Verlag GmbH & Co., Weinheim, 2004.
5. H. Gleiter, 'Progress in materials Science', Vol. 33 (1989).
6. K.L.Chopra,'Thin Film phenomena', McGraw-Hill,1969.
7. Donald L.Smith, 'Thin film deposition:Principles and Practice', McGraw-Hill,1995.
8. George Hass, 'Physics of Thin Films' Volumes 1-12, Academic Press, 1963.
9. Surface Physics of Materials, Vol.I and II (Academic Press).

OUTCOMES:

Students will be able

- to produce ultrahigh vacuum and measure using the pressure gauges
- to understand the thin films preparation methods using physical and chemical methods and differentiate between these methods
- to identify the structural defects in thin films and illustrate the applications of thin Films

PHBY07 NANOSCIENCE AND TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To give thorough knowledge of the general principles of physics, chemistry, electronics and biology that play a role on the nanometer scale.
- To get into Insight of the materials, fabrication and other experimental techniques that can be used on the nanoscale, as well as their limitations.
- To get in-depth knowledge of at least one specialisation area within the field of nanoscience and nanotechnology.
- 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.

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. B S Murty, P Shankar & et al., "Textbook of Nanoscience and Nanotechnology", Universities Press (India) Private Ltd., 2012.
3. Richard Booker and Earl Boysen, "Nanotechlongy", 2005.
4. G Timp (ed), Nanotechnology, AIP press, Springer, 1999.
5. M. Wilson, K. Kannangara, G. Smith, M. Simmons and B. Raguse, Nanotechnology: Basic Sciences and Energy Technologies, Overseas Press, 2005.

OUTCOMES:

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

- the basic concepts about the Nano materials
- the importance of use of nano materials in design and synthesis of novel materials.

PHBY41	MATERIALS PROCESSING	L T P C
		3 0 0 3

OBJECTIVES:

- To make the students understand the physics of materials processing
- To teach the principle behind the different processing techniques.

MODULE I BASIC MANUFACTURING PROCESSES 9

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

MODULE II SURFACE TREATMENT PROCESSES 9

Necessity for surface modification, surface cladding, surface alloying, hard facing, shock hardening, conventional methods, carburising, 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, oxyacetelene welding, resistance welding, spot welding, thermit 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, normalising, 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.

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.

OUTCOMES:

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

- the manufacturing process, surface treatment process
- the welding process and mechanical working of metals, powder metallurgical process.

PHBY42	LASER APPLICATIONS	L T P C
		3 0 0 3

OBJECTIVE:

- To make the students to understand the various applications of Laser

MODULE I METROLOGICAL APPLICATIONS 10

CW and Pulsed laser beam characteristics and its measurements - Beam focusing effects - spot size - Power and Energy density Measurements - Distance measurement - Interferometric techniques – Calibration Methods - LIDARS - Theory and different experimental arrangements - Pollution monitoring by remote sensing - Applications - Laser gyroscope

MODULE II MATERIAL PROCESSING 9

Models for laser heating - Choice of a laser for material processing - Laser welding, drilling, machining and cutting - Laser surface treatment - Laser vapour deposition - Thin film applications.

MODULE III SPECTROSCOPIC APPLICATIONS 9

Photochemical reactions - Steady and excited state techniques - Comparison of one photon and Multiphoton effect and its applications – Photo ionization – Photo isomerism - Isotope separation - Laser fusion – Laser trapping of atoms and cooling.

MODULE IV BIOMEDICAL APPLICATIONS 10

Biological effects of laser radiation - Applications of scattered laser light - Thermal and Non Thermal applications – Biostimulation - Laser Imaging of tissues - Fluorescent Life time Imaging - Optical Coherence Tomography (FLIM-OCT) - Laser hazards and control.

MODULE V LASER INSTRUMENTATION 7

Laser for measurement of length, current and voltage – Laser Doppler Velocimetry - Holography and speckle in displacement and deformation measurements - Laser for communication with fiber optics as channel.

Total Hours:45

REFERENCES :

1. F.T. Arecchi, “Laser Handbook”, Vol.2, North Holland Publication, 1974.
2. R.E. Lidder, McGraw Hill, London, “Fundamental and Applied Laser Physics”, John Wiley, New York, 1985.
3. W.W. Duley, “Laser Processing and Analysis of Materials”, Plenum Press, New York, 1983.
4. J. Wilson & J.F.B. Hawkes, “Opto Electronics - An Introduction”, Prentice Hall, 1992.
5. A.J. Welch and M.J.C.Van Gamert, “Optical Thermal Response of Laser Irradiated Tissue”, Plenum Press, New York, 1995.
6. William M.Steen, ”Laser Material Processing”, Springer-Verlag, Berlin,Third Edn., 2005.

OUTCOMES:

At the end of the course students will be able to

- the laser in metrological and materials application
- the laser in Biomedical and spectroscopic applications
- the laser instrumentation

PHBY43 ELECTRO-OPTIC MATERIALS AND DEVICES **L T P C**
3 0 0 3

OBJECTIVE:

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

MODULE I BASICS OF LASER 9

Laser beam characteristics, modes, noise, types of solid lasers (brief). Symmetry operations and symmetry elements, point groups, tensor properties, dielectric description of a crystal, crystal structure of KDP, BaTiO3 and LiNbO3

MODULE II PROPAGATION OF ELECTROMAGNETIC WAVES 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

Semiconductors - measurement of third order optical non-linearities in semiconductors. Optical switching devices employing optical non-linearities in semiconductors. Glasses - orgin of non-linearity in glasses – SHG - Liquid crystal E-O devices (brief).

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.

OUTCOMES:

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

- electrOptics effect and Acousto –Optics effect
- electro –Optics and Acousto-Optics devices.
- non linear optical materials and devices

PHBY44 CORROSION SCIENCE AND TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To enable the students understand principles behind corrosion science.
- To make the students understand various corrosion processes and engineering applications

MODULE I CORROSION PROCESSES 12

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 ANALYTICAL TECHNIQUES 9

X-ray diffraction, TEM, SEM and EDX, WDX analysis, surface analysis by AES, XPS and SIMS, overview of other techniques.

MODULE III COATING MANUFACTURE 9

Electrodeposition; flame and plasma spraying; thermal, HV of detonation gun, gas dynamic spray, physical vapour deposition; chemical vapour deposition; HIP surface treatments.

MODULE IV CORROSION IN SELECTED ENVIRONMENTS 7

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 COATING APPLICATIONS 8

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.

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.

OUTCOMES:

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

- corrosion process and analytical technique
- application of coatings.
- coating manufacture technique and corrosion environment

PHBY45	NON-DESTRUCTIVE TESTING	L T P C
		3 0 0 3

OBJECTIVES:

- To enable the students understand the principles behind various non-destructive testing methods
- To make the students understand applications of various non-destructive testing methods

MODULE I INTRODUCTION AND SURFACE NDT METHODS 7

Definition of terms, discontinuities and defects/flaws – fracture mechanics concept of design and the role of NDT – life extension and life prediction – penetrant testing and magnetic particle testing, basic principle of penetrant testing – limitations and advantages – basic principle involved in magnetic particle testing – development and detection of large flux – longitudinal and circular magnetization – demagnetization.

MODULE II RADIOGRAPHIC TESTING 12

Electromagnetic spectrum – X-ray and gamma ray sources – X-ray generation – The spectrum of X-rays – Equipment controls – gamma ray sources – properties of X-rays and gamma rays – attenuation and differential attenuation – interaction of radiation with matter – Principle of radiographic testing and recording medium – films and fluorescent screens – nonimaging detectors – film radiography – calculation of exposure for X-ray and gamma rays – quality factors – Image quality indications and their use in radiography.

MODULE III ULTRASONIC TESTING 10

Ultrasonic waves – velocity, period, frequency and wavelength – reflection and transmission – near and far field effects and attenuation – generation – piezoelectric and magnetostriction methods – normal and angle probes – methods of Ultrasonic testing – Principle of pulse echo method – Equipment – examples – rail road inspection, wall thickness measurement – range and choice of frequency.

MODULE IV EDDY CURRENT TESTING 6

Introduction – Principles of eddy current inspection – conductivity of a material – magnetic properties – coil impedance – lift off factor and edge effects – skin effect – inspection frequency – coil arrangements – inspection probes – types of circuit – Reference pieces – phase analysis – display methods – typical applications of eddy current techniques.

MODULE V OTHER METHODS 10

Imaging – principle and applications – testing of composites – acoustic emission testing – application of AET – on-line monitoring or continuous surveillance and applications in materials science – Optical methods of NDT – photo elasticity – evaluation procedure – Holographic NDT procedure – speckle phenomenon – speckle interferometry – speckle shear interferometry – Fourier optics – Fourier filtering techniques for non-destructive testing.

Total Hours:45

REFERENCES:

1. B.Hull and V.John, Nondestructive testing, Mc Millan Education Ltd., London, 1988.
2. Metals Hand Book, Vol.2, 8th Edition, ASTM, Metals Park, Ohio.
3. Dainty, Laser Speckle & Related Phenomena, Springer-Verlag, New York, 1984.
4. Mc Gonnagle, W.J. Non-destructive testing methods, Mc Graw Hill Co., NY, 1961.

OUTCOMES:

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

- principle and construction of various NDT methods.
- importance of NDT in quality assurance.
- application of NDT.

PHBY46 FERROELECTRIC MATERIALS AND DEVICES **L T P C**
3 0 0 3

OBJECTIVES:

- To enable the students understand the principles behind ferroelectric materials.
- To make the students understand materials, devices and applications.

MODULE I INTRODUCTION 9

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

MODULE II MATERIALS AND DEVICE DESIGNING AND FABRICATION PROCESSES 9

Composition selection – Dopant effects – High power characteristics – Ceramic powder preparation – Sintering process – Single crystal growth – Device designing – Single disks – Multilayers – Bimorphs/Moonies – Flexible composites – Thin/Thick films - Effect of grain size- Ferroelectric domains.

MODULE III HIGH PERMITTIVITY DIELECTRICS 9

Ceramic capacitors. Chip capacitors. Hybrid substrate. Relaxor ferroelectrics – High permittivity – Diffuse phase transition – Dielectric relaxation -IK dielectric materials.

FERROELECTRIC MEMORY DEVICES: DRAM – Ferroelectric DRAM – Non volatile ferroelectric memory – FRAM (inversion current type) – MFSFET

PYROELECTRIC DEVICES: Pyroelectric materials – pyroelectric effect – responsitivity – figures of merit. Temperature/infrared light sensors. Infrared image sensors.

MODULE IV PIEZOELECTRIC DEVICES 9

Piezoelectric materials and properties – Figures of Merit. Single crystal – polycrystalline materials relaxor ferroelectricspolymers – composites – Thin films. Pressure sensors, accelerometers, gyroscopes. Piezoelectric vibrators – piezoelectric resonance – equivalent circuits, ultrasonic transducers – Resonators/filters. Surface acoustic wave devices. Piezoelectric transformers. Piezoelectric actuators. Ultrasonic motors.

MODULE V ELECTRO-OPTIC DEVICES 9

Electro-optic effect, transparent electro-optic ceramics, bulk electro-optic devices. Wave-guide modulators.

COMPOSITES: Composite piezoelectric materials, connectivity, composite effects. PZT polymer composites.

Total Hours:45

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.

OUTCOMES:

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

- the principles of ferroelectric materials.
- ferroelectric materials, devices and applications

PHBY47 HIGH PRESSURE SCIENCE AND TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To enable the students understand importance of production and measurement of high pressure.
- To make the students understand the properties and devices of high pressure for various applications.

MODULE I METHODS OF PRODUCING HIGH PRESSURE 8

Definition of pressure – Hydrostaticity – generation of static pressure, pressure MODULEs – piston cylinder – Bridgmann Anvil – Multi-anvil devices – Diamond anvil cell.

MODULE II MEASUREMENT OF HIGH PRESSURE 7

Primary gauge – Secondary gauge – Merits and demerits – Thermocouple pressure gauge – Resistance gauge – fixed point pressure scale – Ruby fluorescence – Equation of state.

MODULE III HIGH PRESSURE DEVICES FOR VARIOUS APPLICATIONS10

X-Ray diffraction, Neutron diffraction – Optical studies – Electrical studies – Magnetic studies – High and low temperature applications – Ultra high pressure anvil devices.

MODULE IV HIGH PRESSURE PHYSICAL PROPERTIES 10

PVT Relation in fluids – Compressibilities of solids – properties of gases under pressure - Melting phenomena – viscosity – thermo emf – thermal conductivity. Electrical conductivity – phase transitions phonons superconductivity – Electronic structure of metals and semiconductors – NMR and magnetic properties. Liquid crystals – spectroscopy studies –Infrared, Raman Optical absorption – EXAFS.

MODULE V MECHANICAL PROPERTIES UNDER PRESSURE 10

Elastic constants – Measurements – mechanical properties – Tension and compression – Fatigue – Creep – Hydrostatic extrusion. Material synthesis – Superhard materials – Diamond – Oxides and other compounds – water jet.

Total Hours: 45

REFERENCES:

1. P.W. Bridgmann, The Physics of High Pressure, G. Bell and SONS Ltd., London, 1931.
2. B.Vodar and Ph. Marteam, High Pressure Science and Technology, Vol.I and II, Pergamon Press, Oxford,1980
3. H. Ll. D. Pugh, Mechanical Behaviour of Materials under Pressure, Elsevier Publishing Co., Ltd., New York, 1970.
4. M.I. Eremets, High pressure Experimental methods, New York, 1996.

OUTCOMES:

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

- understand production and measurement of high pressure.
- understand the properties and devices of high pressure for various applications.

PHBY48 STRUCTURE AND PROPERTIES OF ALLOYS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To enable the students understand importance of phase diagrams and their relationship with properties of alloys
- To make the students understand the basic structure and property relationship of the alloys

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.

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, 1999.
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. Materials 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.

OUTCOMES:

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

- importance of phase diagrams and their relationship with properties of alloys
- basic structure and property relationship of the alloys

PHBY49 ADVANCED MATERIALS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To enable the students understand structure and properties of advanced Materials.
- To make the students understand applications of various advanced materials.

MODULE I NANOSTRUCTURAL MATERIALS 9

Magnetism in particles of reduced size and dimensions - Variations of magnetic moment with size - Magnetism in clusters of non magnetic solids - Magnetic behaviour of small particles - Diluted magnetic semiconductors (DMS) - Fe-DMS and IV -VI Mn DMS and their applications - Intermetallic compounds - Binary and ternaries and their magnetic properties.

MODULE II COMPOSITE MATERIALS 9

Metal matrix composites - Polymer matrix composites - Ceramic matrix composites - Reinforcements - Whisker reinforced ceramics - Carbon-carbon composites - Design of composite materials - Hybrid composites - Angled plied composites- Unidirectional fiber composites - Discontinuous fiber composites - Applications of composites in electrical components and nuclear industry.

MODULE III LIGHT WEIGHT HIGH STRENGTH MATERIALS 9

Properties and structure of Titanium - Alloying elements- manufacture of titanium wrought products - Mechanical properties and microstructure correlation - , and , alloys, aerospace and medical applications - Yttrium based iron-chromium aluminum alloy- mechanical alloying process of MA 956 alloy - MAODS super alloys - High temperature and medical applications.

MODULE IV OPTO ELECTRONIC MATERIALS 9

Injection luminescence and LEDs - LED materials - LED construction - Double heterojunction LED and related materials - Edge emitter and superluminescent LED materials - Liquid crystals-properties and structure-liquid crystal displays - Comparison between LED and LC displays - Optical amplifier - Erbium doped silica fiber.

MODULE V ENGINEERING MATERIALS **9**

Electrets - properties and applications - Metallic glasses - Properties and applications - SMART materials - Piezoelectric, magnetostrictive, electrostrictive materials - Shape memory alloys - Rheological fluids - CCD device materials and applications - Single crystalline solar cells - Amorphous silica solar cells -thin film polycrystalline solar cells -Surface acoustic wave and sonar transducer materials and applications.

Total Hours: 45

REFERENCES:

1. Hand book of Nanophase Materials - edited by Avery N.Goldstain Marcel Dekker Inc, NewYork, 1997.
2. Science and Technology of Nanostructured Magnetic Materials, Ed. George C.Hadjipanayis and Gary A.Prinz, NATO ASI series, Plenum Press, New York,1991.
3. Composite Materials, S.C.Sharma, Narosa Publishing House, New Dellhi,2000.
4. Heat Treatment Structure and properties of non-ferrous, Charlie Brooks. R, American society for metals, U.S.A, 1984.
5. Optical Fiber Communications - John M.Senior, Prentice-Hall of India private Ltd., New Delhi, 1998.
6. Microelectronic Materials - C.R.M.Grovenor, Adam Hilger, Bristol and Philadelphia,1989.

OUTCOMES:

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

- structure and properties of advanced materials
- applications of various advanced materials

PHBY50 SMART MATERIALS AND STRUCTURES **L T P C**
3 0 0 3

OBJECTIVES:

- To enable the students understand importance and structure of smart materials
- To make the students understand the applications of smart materials

MODULE I INTRODUCTION AND HISTO RICAL PERSPECTIVE 9

Classes of materials and their usage – Intelligent /Smart materials – Evaluation of materials Science – Structural material – Functional materials – Polyfunctional 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 SMART 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) SMART 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 Electrorheolgoical fluids.

MODULE IV PIEZOELECTRIC SMART MATERIALS 9

Background – Electrostriction – Pyroelectricity – 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) SMART 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 memorisation process (Satellite antenna applications) SMA blood clot filter – Impediments to applications of SMA – SMA plastics – Primary molding – secondary molding – Potential applications of SMA plastics.

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, Technomic Publising Co., USA, 1989.

OUTCOMES:

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

- importance and structure of smart materials
- the applications of smart materials

PHBY51 **BIOMATERIALS** **L T P C**
3 0 0 3

OBJECTIVES:

- To enable the students understand importance of and properties of Biomaterials
- 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 .

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 OTHER MATERIALS 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.

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. L.L.Hench and E.C.Ethridge. Biomaterials: An Interfacial Approach, Academic Press, 1982.

OUTCOMES:

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

- importance of and properties of biomaterial
- applications of various biomaterials

PHBY52 NUCLEAR PHYSICS AND REACTOR MATERIALS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To enable the students understand the physics of nuclear reactor
- To make the students understand properties of nuclear reactor materials

MODULE I NUCLEAR STRUCTURE AND RADIOACTIVITY 9

Nuclear charge, mass, spin, magnetic moment, electric quadrupole moment, Binding energy, Semi-empirical mass formula – Mass parabola – Applications – Radioactivity – Soddy-Fajans law – Successive disintegration – Transient and secular equilibrium.

MODULE II NUCLEAR MODELS, FORCES AND ELEMENTARY PARTICLES 9

Liquid drop model – Shell model-compound nucleus model – Breit-wigner formula – Mesion theory – Ground state of deutron – Exchange forces – n-p, p-p scattering-Spin dependence – Classification of elementary particles – Conservation laws – elementary idea about quarks, gluons and quantum chromodyamics.

MODULE III NUCLEAR FISSION AND FUSION 9

Types of fission-distribution of fission products – Fissile and fertile materials – Neutron emission in fission – Spontaneous fission – Bohr – Wheeler theory – Chain reaction – Four-factor formula – Criticality condition – Fusion- energy released – Stellar energy – Controlled thermo nuclear reaction – Plasma confinement.

MODULE IV NEUTRON AND REACTOR PHYSICS 9

Nuclear transmutation, Q value – exoergic – Endoergic reactions – Nuclear cross sections – Neutron sources – Classification of neutrons – Thermalisation – Average logarithmic decrement – Thermal neutron diffusion – Fermi age equation.

MODULE V REACTOR DESIGN AND MATERIALS 9

Nuclear materials-Materials for Fuels, moderator, coolants &, shielding – Reactor size – Radioactive waste disposal – Radiation detection and measurement – Film badge – TLD pocket dosimetry – Application of radio isotopes – Irradiation technology – Radiation protection – MODULEs and dosage.

Total Hours: 45

REFERENCES:

1. Evans, Atomic Physics, Tata McGraw Hill, New Delhi, 1986.
2. S.Glasstone, Principles of Nuclear Reactor Engineering, Van Nostrand Co, Inc., New York, 1985.
3. R.R.Roy and B.P.Nigam, Nuclear Physics, Wiley Easter, New Delhi, 1985.
4. D.S.Tayal, Nuclear Physics, Himalaya Publishers, Bombay, 1998.

OUTCOMES:

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

- nuclear structure, nuclear model and nuclear fusion and fission.
- nuclear reactor materials and design.
- neutron and reactor physics.

PHBY53	ULTRASONICS AND APPLICATIONS	L T P C
		3 0 0 3

OBJECTIVES:

- To enable the students understand basics of ultrasonics
- To make the students understand applications of ultrasonics

MODULE I ULTRASONIC TRANSDUCERS 9

Piezoelectric and Magnetostrictive transducers - Equivalent circuits - Efficiency - Transducer mounting - Mechanical and Electronics, Linear and sector transducers - Variable frequency systems.

MODULE II ABSORPTION OF ULTRASONIC RADIATION 9

Classical absorption due to viscosity - Absorption due to thermal conductivity - Relaxation process - Evaluation of dispersion and absorption curves - Structural relaxation - Relation between collision frequency and relaxation time - Ultrasonic attenuation in solids.

MODULE III ULTRASONIC PROPAGATION IN SOLIDS AND LIQUIDS 9

Propagation of Ultrasonic waves in solids - Plane wave propagation - Relation between velocity of sound and elastic properties - Adiabatic and Isothermal elastic constants - Ultrasonic propagation in liquids - Internal pressure and free volume calculations.

MODULE IV DETERMINATION OF VELOCITY OF PROPAGATION OF ULTRASOUND 9

Transit time method - Pulse Echo methods - Acoustic Interferometry - Measurements at high pressure and high temperature - Transducer coupling materials.

MODULE V APPLICATION OF ULTRASONICS 9

Industrial applications - Medical Applications - Acoustic microscope - Acoustic hologram - Ultrasonic transaxial tomography.

Total Hours: 45

REFERENCES:

1. G.L. Gooberman, Ultrasonics - Theory and Applications, - The English Universities Press Ltd., London, 1968.
2. Schreiber, Anderson and Soga, Elastic Constants and Their Measurement, Mc Graw Hill Book Co., New Delhi, 1973.
3. R.A.Lerski (Editor), Practical Ultrasound, IRL Press, Oxford, 1988.
4. Robert T.Beyer and Stephen V. Letcher, Physical Ultrasonics, Academic Press, London, 1969.
5. J.P.Woodcock, Ultrasonics, Adam Hilger Ltd., U.K., 1979.
6. W.J.McGonnagle, Nondestructive Testing Methods, McGraw Hill Book Co., New York, 1961.

OUTCOMES:

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

- principle, properties and construction of ultrasonic waves.
- application of ultrasonic waves.
- ultrasonic instrumentation.