# PONDICHERRY UNIVERSITY
# PUDUCHERRY-605 014

# REGULATIONS, CURRICULAM & SYLLABUS

# B.Tech. - Materials Science and Technology

**PROGRAMME UNDER NATIONAL EDUCATION POLICY (NEP)**

**(From Academic Year 2024-2025 onwards)**

# March 2024

## 1. Conditions for Admission:

**a) Candidates for admission to the first semester of the 8 semester B.Tech. degree programme should be required to have passed:**

The Higher Secondary Examination of the (10+2) curriculum (Academic Stream) prescribed by the different State Boards/ Central Boards or any other examination equivalent there to with minimum of 45% marks (40% marks in case of candidates belonging to reserved category) in aggregate of subjects – Mathematics, Physics and Chemistry.

**b) Candidates for admission through Lateral entry into second year (third semester) of the 8 semester B.Tech. degree programme should be required to have passed:**

Passed Minimum THREE years Diploma /TWO years (Lateral Entry) Diploma in Engg., /Technology examination with at least 50% marks (45% marks in case of candidates belonging to reserved category). The number of students to be admitted by lateral entry depends on the University directions.

## 2. Age Limit:

As per applicable AICTE norms.

## 3. Duration of the Programme :

The Bachelor of Technology degree programme shall extend over a period of 8 semesters spread over 4 academic years – two semesters constituting one academic year. The duration of each semester shall normally be 90 days.

## 4. Program Structure

- The medium of instruction is English.
- A student admitted to the B.Tech. programme in a particular branch of engineering will earn the degree in that branch by fulfilling all the requirements prescribed in the regulations during the course of study.
- The student is also permitted to opt for earning an **Honors degree in the same discipline of Engineering (or) a Minor degree in another discipline of Engineering** in addition to the degree in their own discipline of Engineering. The student will be allowed to exercise this option at the end of first year based on his academic performance in the first year. The students admitted through lateral entry can exercise this option at the end of third semester, based on the GPA scored in the third semester examination.

- The student opting for B.Tech degree with **Honors or B.Tech degree with Minor** is required to earn a minimum of additional 20 credits starting from the **third semester**. The students admitted in the second year through lateral entry and opting for Honors / Minor degree will earn a minimum of additional 20 credits starting from the **third semester**.

## 5. Eligibility for the award of B.Tech. Degree:

No candidate shall be eligible for the award of the degree of Bachelor of Technology, unless he/she has undergone the course for a period of 8 semesters (4 academic years) / 6 semesters (3 academic years for Lateral Entry candidates) in the Faculty of Engineering and has passed the prescribed examinations in all the semesters. Details regarding the possible exit for a B.Tech student – in line with one of the goals of the National Education Policy (NEP) 2020 are provided in section 13.

## 6. Branches of Study:

The University offers B.Tech. programmes in the following branches:

- Computer Science & Engineering
- Electronics & Communication Engineering
- Energy Science and Technology
- Materials Science and Technology

The branch allocation shall be ordinarily done at the time of admission of the candidate to the first semester.

## 7. Course Structure and Subjects of Study:

**Definition of Credit:**

| | |
|---|---|
| 1 Hour Lecture (L) per week | 1 Credit |
| 1 Hour Tutorial (T) per week | 1 Credit |
| 2 Hours Practical (P) per week | 1 Credit |

**Range of Credits:** The total credits of all the branches for the four-year B. Tech. degree Programme shall be in the range of 160 to 172 (Minor variation is allowed as per AICTE guidelines). "Minor Degree or Honors will cumulatively require additional 20 (or) 21 credits in the specified area in addition to the credits essential for obtaining the Under Graduate Degree in Major Discipline".

| Type of Degree | B.Tech (XXX) | B.Tech (XXX) (Hons.) | B.Tech (XXX) with Minor (YYY) |
|---|---|---|---|
| **Credits Requirements** ** | 160 -172 | 160 -172 + (20/21) | 160-172 + (20/21) |

** Minimum credit requirements specified in the AICTE regulations are discipline specific permitting minor deviations from the norms.

The subjects of study shall include theory, practical courses and project work/internships as given in the curriculum and shall be in accordance with the prescribed syllabus.

The curriculum of every programme will have courses that are categorized as follows:

| Sl. No | Category | Minimum Credits # |
|---|---|---|
| 1. | Humanities, Social Sciences and Management Courses (HSM) | 12 |
| 2. | Basic Science Courses (BSC) | 21 |
| 3. | Engineering Science Courses (ESC) | 23-28 |
| 4. | Professional Core Courses (PCC) | 58-72<br>2/3 Theory &<br>1/3 Practical |
| 5. | Professional Elective Courses (PEC) | 9-16 |
| 6. | Open Elective Courses (OEC) | 9 -16 |
| 7. | Professional Activity Courses (PAC)<br>(Includes Project work, Seminar, Internship) | 16-18 |
| 8. | Mandatory Courses (MC)<br>[Environmental Sciences, Sports and Yoga (or) NSS/NCC, Induction Program, Indian Constitution,Essence of Indian Knowledge Tradition, etc.] | 0<br>(6-9 Credits Equivalent) |

# The minimum credit requirement in each category is only normative and the actual credit distribution for various disciplines as specified by AICTE are given in Annexure-1.

***Each course will have either one or more of three components namely Lecture (L), Tutorial (T) and Practice (P). Each course is assigned credits as detailed below:***

- Theory courses will carry either 3 or 4 credits - 3 credits for courses with 3 lecture periods per week and 4 credits for courses with 3 lecture periods and 2 practical period per week.
- Practical courses will normally carry either 1 or 2 credits; 1 credit for courses with 2 hr practice periods per week and 2 credit for courses with 4 hr practice periods per week.
- Out of total credits required for successful completion of the degree, 14 to 22 credits can be assigned for Project work and/or Internship.
- Mandatory non-credit courses carry zero credit.

## 8. Examinations:

The theory and practical examinations shall comprise continuous internal assessment throughout the semester in all subjects as well as university examinations conducted by Pondicherry University at the end of the semester (November / December or April / May).

### 8.1. Evaluation Scheme

All Credit courses are evaluated for 100 marks comprising of Internal assessment and end-semester exam.

For Theory Course, the weightage of internal assessment is 40% and end semester examination is 60%.

For Practical course, the weightage of internal assessment is 60% and end semester examination is 40%.

For Project, the weightage of internal assessment is 60% and end semester examination is 40%.

### 8.2. Internal Assessment (Theory)

Total Internal Assessment mark for a theory course is 40 marks. The breakup is as follows:

| Criteria | Maximum Marks |
|---|---|
| Theory Course<br><br>**Category I. Theory courses:**<br>**Section A:** 5 Questions of 2 Marks each (10 Marks)<br>(Knowledge: 2, Comprehension: 2, Application: 2, Analysis:1)<br><br>**Section B:** 4 out of 5 Questions of 5 Marks each (20 Marks)<br>(Knowledge: 1, Comprehension: 2, Application: 1, Analysis: 1)<br>(**Questions from all units of syllabus)**<br><br>**Category II. Theory cum Practical courses:**<br>**i. Theory component:**<br>Examination shall be conducted for 30 marks and reduced to 25 marks.<br>**ii. Practical Component:**<br>5 Questions of 2 Marks each (10 Marks)<br>Based on Lab experiment, the examination shall be conducted for 10 marks and reduced to 5 marks.<br>**Total Marks: 30 (Theory: 25 Marks + Practical: 05 Marks)** | 30 |
| b) Percentage of Attendance | 5 |
| c) Assignment(s) (In theory only) | 5 |
| **Total** | **40** |

Marks for Attendance are as follows:

| | |
|---|---|
| Below 75% | 0 |
| 75% - 80% | 1 |
| 81% - 85% | 2 |
| 86% - 90% | 3 |
| 91% - 95% | 4 |
| 96% - 100% | 5 |

The Dean/Head of the Dept./Centre of the University schedules the Internal Assessment tests for all courses. All faculty members are expected to conduct this Internal Assessment tests for 2 hours duration. The faculties are also requested to preserve the answer sheets of Internal Assessment tests until declaration of results.

**8.3. Internal Assessment (Laboratory Courses)**

Faculty in-charge of Lab courses shall evaluate the practical course for 60 marks. The break up is as follows:

| **Criteria** | **Maximum Marks** |
|---|---|
| a) Laboratory Exercises and Record | 30 |
| b) Mid-Semester Exam (Average of 2 exams) | 15 |
| c) Internal Viva-Voce | 5 |
| d) Percentage of Attendance | 10 |
| **Total** | **60** |

Marks for Attendance are as follows:

| | |
|---|---|
| Below 75% | 0 |
| 75% - 80% | 2 |
| 81% - 85% | 4 |
| 86% - 90% | 6 |
| 91% - 95% | 8 |
| 96% - 100% | 10 |

### 8.4. Internal Assessment (Project)

The Project work carried out in the eighth semester shall be assessed as follows:

| Criteria | Marks |
|---|---|
| a) Continuous Assessment (Guide) | 25 |
| b) Project Evaluation Committee | 35 |
| **Total** | **60** |

## 8.5 End Semester Exam - Question pattern

The end-semester exam pattern is as follows:

| Course | Maximum Marks |
|---|---|
| a) Theory Course<br>**Category I. Theory courses:**<br>**Section A:** 10 Questions of 2 Marks each (20 Marks)<br>(Knowledge: 3, Comprehension: 2, Application: 3, Analysis:2)<br><br>**Section B:** 05 out of 7 Questions of 4 Marks each (20 Marks)<br>(Knowledge: 1, Comprehension: 2, Application: 1, Analysis:3)<br><br>**Section C:** 02 Either/OR choice questions of 10 Marks each (20 Marks)<br>(Application: 1, Analysis:1)<br>**(Questions from all units of syllabus)**<br><br>**Category II. Theory cum Practical courses:**<br><br>**i. Theory component:**<br>Examination shall be conducted for 60 Marks and reduced to 40 Marks.<br><br>**ii. Practical Component:**<br>Based on Lab experiment result/Observation/Record/Viva-voce exam/Practical exams. The examination shall be conducted for 40 Marks and reduced to 20 Marks.<br>**Total Marks: 60 (Theory: 40 Marks + Practical: 20 Marks)** | 60 |
| b) Practical Course<br>(Based on Lab experiment result/Observation/Record/Practical exam/ Viva-voce) | 40 |
| c) Internship /Project Work<br>(Based on Seminar/Project Work/Project report/Presentation and viva-voce) | 40 |

## 8.6 End- Semester Examination and Evaluation

- End semester examinations shall be conducted for all courses offered in the department/centres after ensuring that the required number of classes and related activities are completed. The duration of the end semester examination may be 3 hours.
- A schedule of End semester examinations will be announced by the department/centre about 15 days ahead of the conduct of examinations.
- The responsibility of question paper setting, invigilation and valuation of answer papers lie with the course teachers. However, all assessments shall be conducted under the uniform practices of the department approved in the programme committee.
- However, the departments/faculty members are free to decide the components of continuous assessment and the methods of assessment based on the nature of the course and are expected to communicate these to students and respective HODs at the beginning of the semester.
- Mid semester /end semester examinations schedule notified by the University in the academic calendar shall be uniformly followed.

## 8.7 Minimum Pass Mark

A student shall be declared to have passed the course only if she/he gets,

- A minimum of 40% marks in both Internal and End semester exams
- Internal marks are carried forward for 3 attempts for qualifying and afterwards the student has to score minimum pass mark from the external exam only.
- For Mandatory Courses, a minimum of 40% mark is required to pass the examination. Accordingly, a Pass or Fail certification will be given without any credit assignment.

## 8.8 Supplementary examination

- A student who gets F grade in a course shall be permitted to register for the supplementary examination in the following semester or in the subsequent semesters.
- A student who gets F grade in a course shall be given an option either to retain the previously awarded continuous assessment mark or to improve it, and the higher mark out of these two options will be considered for the supplementary examination.
- A student who gets Ab grade in a course/practicum/vocational course/internship/ practicum or any other hands-on skill related course is mandated to repeat the course and undergo all the stages of assessment in subsequent semesters.

## 8.9 Attendance Requirement

- No student who has less than 75% attendance in any course shall be permitted to

participate in end semester examination and he/she shall be given 'Ab' grade, -failure due to lack of attendance. He/she shall be required to repeat that course as and when it is offered.

## 8.10 Letter Grades and Grade Points

Performance of students in each paper will be expressed as marks as well as Letter Grades.

| Range of Marks | Assigned Grade | Grade Points |
|---|---|---|
| 91-100 | O (outstanding) | 10 |
| 81-90 | A+ (Excellent) | 9 |
| 71-80 | A (Very good) | 8 |
| 61-70 | B+ (Good) | 7 |
| 51-60 | B (Above average) | 6 |
| 46-50 | C (Average) | 5 |
| 40-45 | P (Pass) | 4 |
| <40 | F (Fail) | 0 |
| **Not Applicable** | Ab (Absent) | 0 |

In case of fractions the marks shall be rounded off to nearest integer. The class interval K will be calculated by the formula given below:

$$K = (X-50)/6$$

Where, X is the highest mark secured.

According to K value, one of the following grading schemes will be followed.

**(i) If K ≥ 5, then the grades shall be awarded as given in Table II.**

| Table II | | |
|---|---|---|
| **Range of Marks in %** | **Letter Grade Points for** | **Letter Grade Points for** |
| X to (X-K)+1 | O | 10 |
| (X-K) to (X-2K)+1 | A+ | 9 |
| (X-2K) to (X-3K)+1 | A | 8 |
| (X-3K) to (X-4K)+1 | B+ | 7 |
| (X-4K) to (X-5K)+1 | B | 6 |
| (X-5K) to 50 | C | 5 |
| 40 – 49 | P | 4 |
| Below 40 | F | 0 |
| Absent (Lack of Attendance) | Ab | 0 |

**(ii) If K<5, then the grades shall be awarded as given in Table III.**

| Table III | | |
|---|---|---|
| **Range of Marks in %** | **Letter Grade Points for** | **Letter Grade Points for** |
| 80-100 | O | 10 |
| 71-79 | A+ | 9 |
| 66-70 | A | 8 |
| 61-65 | B+ | 7 |
| 56-60 | B | 6 |
| 50-55 | C | 5 |
| 40-49 | P | 4 |
| Below 40 | F | 0 |
| Absent (lack of attendance) | Ab | 0 |

The Semester Grade Point Average (SGPA) is computed from the grades as a measure of the student's performance in a given semester. The SGPA is based on the grades of the current term, while the Cumulative GPA (CGPA) is based on the grades in all courses taken after joining the programme of study.

## 8.11 Computation of SGPA and CGPA

The following procedure shall be followed to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

The SGPA is the ratio of the sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student, i.e. **SGPA** $(Si) = \Sigma(Ci \times Gi) / \Sigma Ci$

Where, Ci is the number of credits of the $i^{th}$ course and Gi is the grade point scored by the student in the $i^{th}$ course.

**(i) Example for Computation of SGPA where candidate has not failed in any course.**

| **Semester** | **Course** | **Credit** | **Letter Grade** | **Grade point** | **Credit Point** (Credit x Grade) |
|---|---|---|---|---|---|
| I | Course 1 | 3 | A | 8 | 3 × 8 = 24 |
| I | Course 2 | 4 | B+ | 7 | 4 × 7 = 28 |
| I | Course 3 | 3 | B | 6 | 3 × 6 = 18 |
| I | Course 4 | 3 | O | 10 | 3 × 10 = 30 |
| I | Course 5 | 3 | C | 5 | 3 × 5 = 15 |
| I | Course 6 | 4 | B | 6 | 4 × 6 = 24 |
| | | 20 | | | 139 |
| | SGPA | | | | 139/20=6.95 |

**(ii) Example for Computation of SGPA where candidate has failed in one course.**

| Semester | Course | Credit | Letter Grade | Grade point | Credit Point (Credit × Grade) |
|---|---|---|---|---|---|
| I | Course 1 | 3 | A | 8 | 3 × 8 = 24 |
| I | Course 2 | 4 | B+ | 7 | 4 × 7 = 28 |
| I | Course 3 | 3 | B | 6 | 3 × 6 = 18 |
| I | Course 4 | 3 | O | 10 | 3 × 10 = 30 |
| I | Course 5 | 3 | C | 5 | 3 × 5 = 15 |
| I | Course 6 | 4 | F | 0 | 4 × 0 = 00 |
| | | 20 | | | 115 |
| | SGPA | | | | 115/20=5.75 |

**(iii) Example for Computation of SGPA where candidate has failed in two courses.**

| Semester | Course | Credit | Letter Grade | Grade point | Credit Point (Credit × Grade) |
|---|---|---|---|---|---|
| I | Course 1 | 3 | A | 8 | 3 × 8 = 24 |
| I | Course 2 | 4 | B+ | 7 | 4 × 7 = 28 |
| I | Course 3 | 3 | F | 0 | 3 × 0 = 00 |
| I | Course 4 | 3 | B | 6 | 3 × 6 = 18 |
| I | Course 5 | 3 | C | 5 | 3 × 5 = 15 |
| I | Course 6 | 4 | F | 0 | 4 × 0 = 00 |
| | | 20 | | | 85 |
| | SGPA | | | | 85/20=4.25 |

The CGPA shall also be calculated in similar way as shown in examples (i), (ii) and (iii) of SGPA for all subjects taken by the students in all the semesters. However, if any student fails more than once in the same subject, then while calculating CGPA, the credit and grade point related to the subject in which the student fails in multiple attempts will be restricted to one time only. The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

In case of audit courses offered, the students may be given (P) or (F) grade without any credits. This may be indicated in the mark sheet. Audit courses will not be considered towards the calculation of CGPA.

## 8.12 Grade Card

The University shall issue a Grade card for the students, containing the marks and grades obtained by the student in the previous Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA).

The grade card shall list:

a. The title, semester and course code of the courses taken by the student.
b. The credits associated with the course.
c. The marks and grade secured by the student.
d. The total credits earned by the student in that semester
e. The SGPA of the student.
f. The total credits earned by the students till that semester.

g. The CGPA of the student.

On successful completion of the programme, students with a CGPA of 9.00 and above who passed all the courses in first attempt shall be awarded the degree in First Class with Distinction. University Rank in a programme will be awarded to the student who secures the highest CGPA in a batch and passed all the courses in first attempt.

Students with CGPA between 6.00 and 8.99 shall be placed in **First Class,**
Students with CGPA between 5.00 and 5.99 shall be placed in **Second Class**, and
Students with CGPA between 4.00 and 4.99 shall be placed in **Pass Class**.

## 9. Procedure for completing the B. Tech. Course:

A candidate can join/rejoin the course of study of any semester only at the time of its normal commencement and only if he/she has satisfied the course requirements for the previous semester and further has registered for the university examinations of the previous semester in all the subjects as well as all arrear subjects if any.

However, the entire B.Tech. course should be completed within 7 years (14 semesters) and six years (12 semesters) for students admitted under lateral entry.

## 10 Award of Class and Rank in B.Tech. degree:

i) A candidate who satisfies the course requirements for all semesters and who passes all the examinations prescribed for all the eight semesters (six semesters for lateral entry candidates) within a maximum period of 7 years (6 years for lateral entry candidates) reckoned from the commencement of the first semester to which the candidate was admitted shall be declared to have qualified for the award of B.Tech. degree.

ii) A candidate who qualifies for the award of the B.Tech. degree passing in all subjects pertaining to the semesters 3 to 8 in his/her first appearance within 6 consecutive semesters (3 academic years) and in addition secures a CGPA of 8.50 and above for the semesters 3 to 8 shall be declared to have passed the examination in **FIRST CLASS** with **DISTINCTION**.

iii) A candidate who qualifies for the award of the B.Tech degree by passing in all subjects relating to semesters 3 to 8 within a maximum period of eight semesters after his/her commencement of study in the third semester and in addition secures CGPA not less than 6.0 shall declared to have passed the examination in **FIRST CLASS**.

iv) All other candidates who qualify for the award of B.Tech. degree shall be declared to have passed the examination in **SECOND CLASS**.

v) For the Award of University ranks and Gold Medal for each branch of study, the CGPA secured from the 1st to 8th semester alone should be considered and it is mandatory that the candidate

should have passed all the subjects from the 1st to 8th semester in the first attempt. Rank certificates would be issued to the first ten candidates in each branch of study.

## 11. Provisions for Honors/Minor degree along with B.Tech. degree:

### 11.1 B.Tech. with Honors Degree in the same Engineering discipline

- The student shall be given an option to earn an Honors degree in the same discipline of Engineering at the end of first year based on his academic performance in the first year.
- A student is eligible to exercise this option if he has passed all the subjects offered in the first year and has earned a CGPA of not less than 7.5.
- The student is required to earn an additional, a minimum of 20 credits (over and above the prescribed maximum credits in the curriculum) starting from the third semester onwards to become eligible for the award of Honors degree. A minimum of 20 credits shall be earned by the student by completing a minimum of 5 (or) 6 additional courses of 4 credits each, one in each of the 5 semesters starting from the third to seventh semester. The syllabuses of these minimum of 5 courses are framed so as to cover advanced topics in that discipline of Engineering.
- The students admitted in the second year through Lateral Entry Scheme will also be given a chance to opt for Honors degree. Eligibility to avail this option is CGPA of 7.5 and above with no arrears in the third Semester. The student will join the existing batch of students in the fourth semester and earn 16 credits by registering the prescribed courses offered up to the seventh semester. The respective BoS will decide on a suitable course in lieu of the course offered in the third semester to facilitate the student to earn the remaining 4 credits.
- A student is eligible to get the Honors degree only on completing the programme in 'First Class with Distinction' class.
- A student can exercise the option to withdraw from the Honors degree at any time after entry.
- Details about the courses completed and credits earned for Honors degree will appear only in the 'Eighth Semester Grade Sheet' and 'Consolidated Grade Sheet'. These details will be listed under the heading 'Credits Earned for Honors degree'. In the case of students who have either withdrawn from Honors degree or become ineligible for Honors degree by not securing 'First Class with Distinction', the credits earned for the courses registered and successfully completed for Honors degree will be listed under the heading 'Additional Credits Earned'.
- The CGPA will be calculated for all the courses credited by the students inclusive of major and honors courses.
- Nomenclature of Honors Degree is 'B.Tech.(Honors) in XXX', where XXX is Discipline in which the student has enrolled.

### 11.2 B.Tech. with Minor degree in another Engineering discipline

- The student shall be given an option to earn a minor degree in another Engineering discipline of student choice at the end of first year based on his academic performance in the first year.
- A student is eligible to exercise this option if he has passed all the subjects offered in the first year in the first attempt itself and has earned a CGPA of not less than 7.5.
- Minor degree in a particular discipline of engineering shall be offered for a batch of students if and only if a minimum of 5 eligible students opts for it.
- The student is required to earn an additional 20 (or) 21 credits (over and above the prescribed maximum credits in the curriculum) starting from the third semester onwards to become eligible for the award of minor degree. 20 (or) 21 credits shall be earned by the student by completing 5/6 additional courses starting from the third to seventh semester. The curricular content of these 5/6 courses are framed in such a way that that these courses will essentially cover the core minimum knowledge required to be fulfilled for award of degree in the discipline of engineering in which the student chooses to earn the minor degree.
- The students admitted in the second year through Lateral Entry Scheme will also be given a chance to opt for Minor degree. Students with a CGPA of 7.5 and with no arrears in the third semester are eligible to avail this option. The student will join the existing batch of students in the fourth semester and earn 16 credits by registering for prescribed courses offered up to seventh semester. The respective BoS will decide on a suitable course in lieu of the course offered in the third semester to facilitate the student to earn the remaining 4 credits.
- A student can exercise the option to withdraw from the Minor degree at any time after entry.
- Details about the courses completed and credits earned for Minor degree will appear only in the ‘Eighth Semester Grade Sheet’ and ‘Consolidated Grade Sheet’. These details will be listed under the heading ‘Credits Earned for Minor degree’. In the case of students who have withdrawn from Minor degree, the credits earned for the courses registered and successfully completed for Minor degree will be listed under the heading ‘Additional Credits Earned’.
- Nomenclature of Minor Degree is ‘B.Tech. in XXX with Minor in YYY’, where XXX is Discipline in which the student is enrolled and YYY is Discipline which the student has opted as Minor.
- The CGPA will be calculated for all the courses credited by the students inclusive of major and minor courses.

## 12. Provision for withdrawal:

Based on the recommendation of the Head of the Institution, a candidate with valid reasons may be granted permission by the University to withdraw from writing the entire semester examination. The withdrawal application shall be valid only if it is made earlier than the commencement of the last theory examination pertaining to that semester. Withdrawal shall be permitted only once during the

entire program. A candidate who has withdrawn is also eligible to be awarded DISTINCTION provided the candidate satisfies the other necessary conditions. But, they are not eligible to be awarded a rank.

## 13. Provisions for exits in B.Tech. course:

**(For courses where AICTE specifies exit in the model curriculum)**

The curriculum and the syllabus for all B.Tech. programmes have been planned in compliance with the NEP guidelines proposed by AICTE. Accordingly, students joining B.Tech. programmes shall have all benefits NEP offers in terms of exercising exit option during the course of study. Every B.Tech programme governed under this school board shall adopt the NEP guidelines, as and when proposed/amended by AICTE, and the following scheme will be applied for all such B.Tech. programmes specified by AICTE.

NEP 2020 suggests that a student can exercise exits at multiple stages of the course of study. As per AICTE norms, a student can have two possible exits before the completion of the Full Engineering degree and may get a UG Diploma /Certificate or B.Voc. degree in the relevant discipline if he/she fulfils the following conditions: (Subject to change as per AICTE guidelines).

### 13.1 Diploma/Certificate in the relevant branch of study

**A student should be able to get a Certificate if he/she completes:**

After completion of first year, the students should complete 2 additional courses at the ITI level of any suitable skill based courses with a minimum of 6 credits to qualify for the Certification.

**A student should be able to get a Diploma if he/she completes:**

After the completion of second year, the students should complete 2 additional courses at the Diploma level or any 2 suitable skill based courses with a minimum of 6 credits to qualify for the Diploma.

### 13.2 B.Voc. in the relevant branch of study

After the completion of third year, the students should complete 2 additional courses at the Degree level or any 2 suitable skill based courses with a minimum of 6 credits to qualify for the B.Voc.

### 13.3 Award of Class in B.Voc. degree

A candidate who satisfies the course requirements for all semesters and who passes all the examinations within a maximum period of 6 years (5 years for lateral entry candidates) reckoned from the commencement of the first semester to which the candidate was admitted shall be declared to have qualified for the award of B.Voc. degree in the relevant discipline.

- A candidate who qualifies for the award of the B.Voc. degree passing in all subjects pertaining to semesters the 3 to 6 in his/her first appearance within 4 consecutive semesters (2 academic

years ) and in addition secures a CGPA of 8.50 and above for the semesters 3 to 6 shall be declared to have passed the examination in **FIRST CLASS** with **DISTINCTION**.

- A candidate who qualifies for the award of the B.Voc. degree by passing in all subjects relating to semesters 3 to 6 within a maximum period of six semesters after his/her commencement of study in the third semester and in addition secures CGPA not less than 6.5 shall declared to have passed the examination in **FIRST CLASS.**
- All other candidates who qualify for the award of B.Voc. degree shall be declared to have passed the examination in **SECOND CLASS**

### 13.4 Re-entry to complete the program

A student exiting with B.Voc. should be entitled to re-enrol in the programme of the same Engineering discipline. Only students admitted to the B.Tech. programme and exercised an exit option are eligible for readmission to the B.Tech. programme under the same discipline. It is suggested that all credits will be transferred, if the student enrols back within a limited period (3 years) of exiting. In case a student enrols after that, then the decision on the transfer of credits should be based on the changes in the curriculum the student studied. A candidate after exit may rejoin the program only at the commencement of the semester at which he/she discontinued, provided he/she pays the prescribed fees to the University. The total period of completion of the B.Tech. program reckoned from the commencement of the first semester to which the candidate was admitted shall not in any case exceed 7 years, including of the period of discontinuance.

### 13.5 Completion Possibility in other Institutions

A student can earn B.Voc. in one institution (Engineering) and complete the degree program in another institution (same Engineering discipline only).

*(Note: If these exit options are accepted for multiple B.Tech. programs, it is suggested that AICTE actively communicate these to the industry and other bodies, so they recognize these and accept them as bona-fide credentials for the purposes of recruitment and/or eligibility for admission to programs, appearing in competitive examinations, etc*.).

## 14. Academic Bank of Credits (ABC)

The scheme of Academic Bank of Credits (ABC) for students as per NEP 2020 will promote flexibility in curriculum to

(i) provide option of mobility for learners across any Higher Education Institutes (HEIs) of their choice.

(ii) provide option to gain the credits through the approved digital platforms such as NPTEL,

SWAYAM, MOOCs etc.

(iii) facilitate award of certificate/diploma/degree in line with the accumulated credits in ABC.

(iv) execute Multiple Entry and Exit system with credit count, and credit transfer.

## 15. Revision of Regulations and Curriculum:

The University may from time-to-time revise, amend or change the regulations of curriculum and syllabus as and when found necessary.

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# Centre for Nanoscience and Technology
# Madanjeet School of Green Energy Technologies
# Pondicherry University

## B.Tech. - Materials Science and Technology

## PROGRAMME STRUCTURE

**A. Definition of Credit:**

| | |
|---|---|
| 1 Hr. Lecture (L) per week | 1 Credit |
| 1 Hr. Tutorial (T) per week | 1 Credit |
| 1 Hr. Practical (P) per week | 0.5 Credit |
| 2 Hours Practical (P) per week | 1 Credit |

**B. Range of Credits: A** typical Model Four-year Under Graduate degree program in Materials Science and Technology has about 160 credits

**C. Structure of UG Program:** The structure of B.Tech. program in Materials Science and Technology shall have essentially the following categories of courses with the breakupof credits as given:

| S.No. | Category | Suggested Breakup of Credits (Total 160) |
|---|---|---|
| 1 | Humanities, Social Sciences and Management Courses (HSMC) | 12 |
| 2 | Basic Science Courses (BSC) | 22 |
| 3 | Engineering Science Courses Including Workshop, Drawing, Basics of Electrical & Electronics/Mechanical/Computer etc. (ESC) | 28 |
| 4 | Professional Core Courses (PCC) | 61 |
| 5 | Professional Elective Courses Relevant to Chosen Specialization/Branch (PEC) | 12 |
| 6 | Open Electives from other Technical and /or Emerging Subjects (OEC) | 9 |
| 7 | Project Work, Seminar and Internship in Industry (or) Elsewhere | 16 |
| 8 | Mandatory Courses [Environmental Sciences, Sports and Yoga (or) NSS/NCC, Induction Program, Indian Constitution, Essence of Indian Knowledge Tradition, etc.] | 0 |
| | **Total Credits** | **160** |

## Category-Wise Courses

### HUMANITIES, SOCIAL SCIENCES & MANAGEMENT COURSES [HSMC]

**(Total 4 Courses to be taken; 2 Compulsory Courses + 2 Other Courses)**

| Sl. | Code No. | Subject | Semester | Credits |
|---|---|---|---|---|
| 1 | HSMC 101 | Communicative English (Compulsory) | 2 | 3 |
| 2 | HSMC 102 | Universal Human Values-II (Compulsory) | 2 | 3 |
| 3 | HSMC 303 | Industrial Psychology | 5 | 3 |
| 4 | HSMC 304 | Professional Ethics | 5 | 3 |
| 5 | HSMC 305 | Project Management | 6 | 3 |
| 6 | HSMC 306 | Finance & Accounting | 6 | 3 |
| | | | **Total Credits:** | **12** |

### BASIC SCIENCE COURSES [BSC]

**(All 8 Courses to be taken; All Courses are Compulsory)**

| Sl. | Code No. | Subject | Semester | Credits |
|---|---|---|---|---|
| 1 | BSC 101 (PHYS 105) | Physics | 1 | 3 |
| 2 | BSC 102 (PHYS 102) | Lab | 1 | 2 |
| 3 | BSC 103 (**MATHE 111**) | Mathematics- I | 1 | ~~3~~4 |
| 4 | BSC 104 | Biology for Engineers | 1 | 3 |
| 5 | BSC 105 | Engineering Chemistry | 2 | 3 |
| 6 | BSC 106 | Engineering Chemistry Lab | 2 | 2 |
| 7 | BSC 107 (**MATHE 121**) | Mathematics- II | 2 | ~~3~~4 |
| 8 | BSC 208 (**MATHE 133**) | Mathematics- III | 3 | ~~3~~4 |
| | | | **Total Credits:** | **~~22~~ 25** |

### ENGINEERING SCIENCE COURSES [ESC]

**(All 8 Courses to be taken; 1 Compulsory Course +7 Other Courses)**

| Sl. | Code No. | Subject | Semester | Credits |
|---|---|---|---|---|
| 1 | ESC 101 | Basic Electronics Engineering | 1 | 4 |
| 2 | ESC 102 | Engineering Graphics & Design | 1 | 4 |
| 3 | ESC 103 | Basic Electrical Engineering | 2 | 4 |
| 4 | ESC 104 | Programming for Problem Solving | 2 | 4 |
| 5 | ESC 105 | Workshop/Manufacturing Practices | 2 | 4 |
| 6 | ESC 106 | Design Thinking + Idea Lab (Compulsory) | 2 | 2 |

| | | | | |
|---|---|---|---|---|
| 7 | ESC 207 | Engineering Mechanics* | 3 | 3 |
| 8 | ESC 208 | Applied Thermodynamics* | 3 | 3 |
| | | | **Total Credits:** | **28** |

(*It will be different for other disciplines; For example, CSE, ECE etc., except MST and EE).

## MANDATORY COURSES [MC]

**(Minimum 2 Courses to be taken as compulsory)**

| Sl. | Code No. | Subject | Semester | Credits |
|---|---|---|---|---|
| 1 | MC 101 | Induction Program **(Three weeks duration)** | 1 | 0 |
| 2 | MC 102 | Sports & Yoga (or) NSS/NCC | 1 | 0 |
| 3 | MC 203 | Environmental Sciences | 3/4 | 0 |
| 4 | MC x04 | Indian Constitution (or) Essence of Indian Knowledge Tradition | 5/6/7 | 0 |
| | | | **Total Credits:** | 0 |

## PROFESSIONAL CORE COURSES [PCC]

**( 19 Courses to be taken with the total credits of 61)**

| Sl. | Code No. | Subject | Semester | Credits |
|---|---|---|---|---|
| 1 | PCC- MST 201 | Physics and Chemistry of Materials | 3 | 4 |
| 2 | PCC- MST 202 | Solid and Fluid Mechanics | 3 | 4 |
| 3 | PCC- MST 203 | Materials Testing Lab | 3 | 2 |
| 4 | PCC- MST 204 | Phase Transformation and Phase Equilibrium in Materials | 4 | 4 |
| 5 | PCC- MST 205 | Diffusion and Heat Treatment of Materials | 4 | 4 |
| 6 | PCC- MST 206 | Ceramic and Glass Materials | 4 | 4 |
| 7 | PCC- MST 207 | Fundamentals of Materials Processing | 4 | 3 |
| 8 | PCC- MST 208 | Materials Processing Lab | 4 | 2 |
| 9 | PCC- MST 309 | Materials Selection and Design | 5 | 3 |
| 10 | PCC- MST 310 | Materials for Electrical, Electronics, Magnetic and Optical Technology | 5 | 4 |
| 11 | PCC- MST 311 | Polymeric Science and Technology | 5 | 3 |
| 12 | PCC- MST 312 | Composite Materials | 5 | 3 |
| 13 | PCC- MST 313 | Characterization of Materials | 5 | 3 |
| 14 | PCC- MST 314 | Semiconductor Devices Lab | 5 | 2 |
| 15 | PCC- MST 315 | Fundamentals of Nanomaterials | 6 | 3 |
| 16 | PCC- MST 316 | Synthesis, Characterization of Nanomaterials and Device Fabrication | 6 | 4 |
| 17 | PCC- MST 317 | Corrosion Science and Engineering | 6 | 4 |
| 18 | PCC- MST 318 | Bio-Materials | 6 | 3 |

| | | | | |
|---|---|---|---|---|
| 19 | PCC- MST 319 | Materials Synthesis and Characterization Lab | 6 | 2 |
| **Total Credits:** | | | | **61** |

**PROFESSIONAL ELECTIVES [PEC]**
**(Total 3/4 Courses to be taken with the total credits of 12)**

| Sl. | Code No. | Subject | Semester | Credits |
|---|---|---|---|---|
| *TECHNOLOGY/ INDUSTRY SECTOR BASED* | | | | |
| 1 | PEC -MST 201 | Computational Methods in Engineering | 3/**4** | 4 |
| 2 | PEC - MST 202 | Additive Manufacturing | 3/**4** | 4 |
| 3 | PEC - MST 203 | Iron and Steel Making | 3/**4** | 4 |
| 4 | PEC - MST 410 | Thin Film Technology | 7/8 | 4 |
| 5 | PEC - MST 411 | Sensor Materials and Technologies | 7/8 | 4 |
| 6 | PEC - MST 412 | Extractive and Powder Metallurgies | 7/8 | 4 |
| 7 | PEC - MST 413 | Rubber Technology | 7/8 | 3 |
| 8 | PEC - MST 414 | Modern Manufacturing Process | 7/8 | 3 |
| 9 | PEC - MST 415 | Micro- and Nano-Fluidics | 7/8 | 3 |
| 10 | PEC - MST 416 | Semiconductor Materials and Devices | 7/8 | 3 |
| 11 | PEC - MST 417 | Industrial Electrochemical Technology | 7/8 | 4 |
| 12 | PEC- MST 418 | Materials for Clean Energy Conversion & Storage Devices | 7/8 | 4 |
| 13 | PEC - MST 419 | Non-destructive Techniques | 7/8 | 4 |
| 14 | PEC –MST 420 | Advanced Nanobiotechnology | 7/8 | 4 |
| 15 | PEC -MST 421 | Industrial Nanotechnology | 7/8 | 3 |
| | | **Total Credits (To be Taken)** | | **12** |

**OPEN ELECTIVE COURSES**
**(03 Courses from any Other Departments with the total credits of 9)**

| Sl. | Code No. | Subject | Semester | Credits |
|---|---|---|---|---|
| 1 | OEC XX 401 | From Other Department | 7/8 | 3 |
| 2 | OEC XX 402 | From Other Department | 7/8 | 3 |
| 3 | OEC XX 403 | From Other Department | 7/8 | 3 |
| 4 | OEC XX 404 | From Other Department | 7/8 | 3 |
| | | **Total Credits (Minimum):** | | **9** |

**ENGINEERING PROJECT**

**(All 4 Courses to be taken as compulsory with the total the total credits of 16)**

| Sl. | Code No. | Subject | Semester | Credits |
|---|---|---|---|---|
| 1 | PROJ-MST 301 | Micro Project | 6 | 2 |
| 2 | PROJ-MST 402 | Mini Project | 7 | 5 |
| 3 | PROJ-MST 403 | Seminar | 7 | 1 |

| | | | | |
|---|---|---|---|---|
| 4 | PROJ- MST 404 | Major Project | 8 | 8 |
| | | | **Total Credits:** | **16** |

# PROFESSIONAL ELECTIVES FOR HONORS IN MATERIALS SCIENCE AND TECHNOLOGY

## Honors Course Basket [HCB]

***(Minimum of 05 or 06 courses to be taken; The students who are opting to take Honors degree must acquire minimum of 20 credits. Registration is Mandatory on the 3$^{th}$ semester)***

| Sl. | Code No. | Subject | Semester | Credits |
|---|---|---|---|---|
| 1 | HC -MST 201 | Computational Methods in Engineering | 3/**4** | 4 |
| 2 | HC- MST 202 | Additive Manufacturing | 3/**4** | 4 |
| 3 | HC - MST 203 | Iron and Steel Making | 3/**4** | 4 |
| 4 | HC- MST 204 | Magnetic Materials and Devices | 3/4 | 3 |
| 5 | HC -MST 305 | Nanoelectronics and Nanophotonics | 5/6 | 3 |
| 6 | HC-MST 306 | Mechanical Behaviour of Materials | 5/6 | 4 |
| 7 | HC-MST 307 | Micro-Electro Mechanical Systems (MEMS) | 5/6 | 3 |
| 8 | HC-MST 308 | Surface Engineering | 5/6 | 3 |
| 9 | HC-MST 309 | Electrochemical Process Technology | 5/6 | 3 |
| 10 | HC -MST 410 | Thin Film Technology | 7/8 | 4 |
| 11 | HC - MST 411 | Sensor Materials and Technologies | 7/8 | 4 |
| 12 | HC - MST 412 | Extractive and Powder Metallurgies | 7/8 | 4 |
| 13 | HC - MST 413 | Rubber Technology | 7/8 | 3 |
| 14 | HC – MST 414 | Modern Manufacturing Process | 7/8 | 3 |
| 15 | HC - MST 415 | Micro- and Nano-Fluidics | 7/8 | 3 |
| 16 | HC - MST 416 | Semiconductor Materials and Devices | 7/8 | 3 |
| 17 | HC – MST 417 | Industrial Electrochemical Technology | 7/8 | 4 |
| 18 | HC – MST 418 | Materials for Clean Energy Conversion & Storage Devices | 7/8 | 4 |
| 19 | HC- MST 419 | Non-destructive Techniques | 7/8 | 4 |
| 20 | HC – MST 420 | Advanced Nanobiotechnology | 7/8 | 4 |
| 21 | HC–MST 421 | Industrial Nanotechnology | 7/8 | 3 |
| | | | **Total Credits:** | **21** |

***MST-Materials Science and Technology, EE –Energy Engineering, CST-Computer Science and Engg., ECE-Electronics and Communication Engg., etc.***

# Minor Program

For B.Tech with MAJOR and MINOR in any one other programs from the below given minor course basket, student must acquire an additional of 21 credits from the respective chosen **Minor Course Basket.** These students must acquire a total of 160+21 credits.

### Minor Programs are:

- Energy Engineering

- Environmental Engineering and Management.
- Electronics and Communication Engineering

## Minor in Materials Science and Technology
## MINOR COURSE BASKET

*[Minimum 06 courses to be taken; The other Dept. students who opting to take MINOR PROGRAM must acquire a minimum of 21 credits. Registration is mandatory on 3$^{th}$ Semester for MINOR PROGRAM]*

| Sl. | Code No. | Subject | Semester | Credits |
|---|---|---|---|---|
| **COMPULSORY CORE COURSES** | | | | |
| 1 | MCC -MST 201 | Physics and Chemistry of Materials | **3**/4 | 4 |
| 2 | MCC -MST 316 | Synthesis, Characterization of Nanomaterials and Device Fabrication | 5/**6** | 4 |
| **OPTIONAL CORE COURSES (Any 2 (or) 3 Courses to be taken)** | | | | |
| 3 | MCC- MST 202 | Solid and Fluid Mechanics | 3/**4** | 4 |
| 4 | MCC- MST 204 | Phase Transformation and Phase Equilibrium in Materials | 3/**4** | 4 |
| 5 | MCC- MST 309 | Materials Selection and Design | **5**/6 | 3 |
| 6 | MCC- MST 310 | Materials for Electrical, Electronics, Magnetic and Optical Technology | **5**/6 | 4 |
| 7 | MCC- MST 311 | Polymeric Science and Technology | **5**/6 | 3 |
| 8 | MCC- MST 312 | Composite Materials | **5**/6 | 3 |
| 9 | MCC- MST 315 | Fundamentals of Nanomaterials | 5/**6** | 3 |
| 10 | MCC- MST 317 | Corrosion Science and Engineering | 5/**6** | 3 |
| 11 | MCC- MST 318 | Bio-Materials | 5/**6** | 3 |
| **ELECTIVE COURSES (Any 1 Course to be taken)** | | | | |
| 12 | MEC -MST 411 | Sensor Materials and Technologies | 7/8 | 4 |
| 13 | MEC- MST 417 | Industrial Electrochemical Technology | 7/8 | 4 |
| 14 | MEC -MST 418 | Materials for Clean Energy Conversion and Storage Devices | **7**/8 | 4 |
| 15 | MEC -MST 420 | Advanced Nanobiotechnology | 7/8 | 4 |
| | | | **Total Credits:** | **21** |

***MST-Materials Science and Technology, EE –Energy Engineering, CST-Computer Science and Engg., ECE-Electronics and Communication Engg., etc.***

## INDUCTION PROGRAM

The Essence and Details of Induction program can also be understood from the 'Detailed Guide on Student Induction program', as available on AICTE Portal,
(Link:https://www.aicteindia.org/sites/default/files/Detailed%20Guide%20on%20Student%20Induction%20program.pdf).

| Induction program (Mandatory) | Three-week duration |
|---|---|
| Induction program for students to be offered right at the start of the first year. | • Physical activity<br>• Creative Arts<br>• Universal Human Values<br>• Literary<br>• Proficiency Modules<br>• Lectures by Eminent People<br>• Visits to local Areas<br>• Familiarization to Dept./Branch & Innovations |

**Mandatory Visits/ Workshop/Expert Lectures:**

**a.** It is mandatory to arrange one industrial visit every year for the students of each branch.

**b.** It is mandatory to conduct a one-week workshop during the winter break after 5$^{th}$ semester on professional/ industry/ entrepreneurial orientation.

**c.** It is mandatory to organize at least one expert lecture per semester for each branch by inviting resource persons from domain specific industry/reputed research institutions.

**Evaluation Scheme (Suggestive only):**

**d. For Theory Courses:**
(The weightage of Internal assessment is 40% and for End Semester Exam is 60%).
The student has to obtain at least 40% marks individually both in internal assessment and End semester exams to pass.

**e. For Practical Courses:**
**(**The weightage of Internal assessment is 60% and for End semester exam is 40%).
The student has to obtain at least 40% marks individually both in internal assessment and end semester exams to pass.

**f. For Summer Internship / Projects / Seminar etc.**
Evaluation is based on work done, quality of report, performance in viva-voce presentation etc.

**Note:** The internal assessment is based on the student's performance in mid semester tests (twobest out of three), quizzes, assignments, class performance, attendance, viva-voce in practical, lab record, etc.

**g. Mapping of Marks to Grades**

Each course (Theory/Practical) is to be assigned 100 marks, irrespective of the number ofcredits, and the mapping of marks to grades may be done as per the following table:

| Range of Marks | Assigned Grade |
|---|---|
| **91-100** | $A^+$ |
| **81-90** | A |
| **71-80** | $B^+$ |
| **61-70** | B |
| **51-60** | $C^+$ |
| **46-50** | C |
| **40-45** | D |
| **< 40** | F (Fail due to less marks) |
| **-** | FA (Fail due to shortage of attendance and therefore, to repeat the course) |

**h. Open Electives Course (OEC):** Any **3** courses (from any department), based on their interest andproject. Students can opt one OEC in online (SWAYAM /NPTEL/MOOC) mode. Students can register OECs even from their $6^{th}$ semester onwards. They can complete OEC-3 in the $6^{th}$ (or) $7^{th}$ semester, so that they can do their project work at any outside institute/industry with the consent of the Faculty in-charge.

**i. Projects**

**Mini Research Project**

• Students may undertake mini research project under the direction of the faculty in- charge, normally 3 hrs/week.
• Submit a detailed report describing the project and results has to be submitted to the Department.
• Presentation of the entire work is to be done before the evaluation committee and a successful oral defence of the project work before the committee.

**Minor Research Project**

• Students may undertake minor/short research project under the direction of the faculty in- charge, normally 3 hrs/week.
• Submit a detailed report describing the project and results has to be submitted to the Department.
• Presentation of the entire work is to be done before the evaluation committee and a successful oral defence of the project work before the committee.

**Seminar**

• For seminar, each student shall prepare a paper on any topic of interest in the field of specialization – Materials Science and Technology.
• He/she shall get the paper approved by the faculty in-charge and present it in the class in the presence of Faculty in-charge of seminar class.
• Every student shall participate in the seminar. Grade will be awarded on the basis of the student's paper presentation and his/her participation in the seminar.

**Major Research Project**

• Students are required to carry out a research project for one full semester related to Materials Science and Technology and submit a project report describing the details of the entire project work has to be submitted to the Department, usually in a prescribed format.

• Each student is assigned with a supervisor from among the faculty members of the CNST of Pondicherry University.
• Arrangement could also be made to pursue research project at institutions other than the CNST of PU. In such circumstance, the student is assigned with two supervisors; an internal supervisor/advisor from the CNST of PU and an external supervisor from the institutions where the research project is carried out.
• Presentation of the entire work is to be done before the evaluation committee and a successful oral defence of the project work before the committee.

**j. Internship**: Internship in industry, start-up or R&D lab in $2^{nd}/3^{rd}$ year summer for 4-6 weeks is compulsory (audit). The internshipmust be properly evaluated.

| Course Code | Definition |
|---|---|
| L | Lecture |
| T | Tutorial |
| P | Practical |
| C | Credits |
| BSC | Basic Science Courses |
| ESC | Engineering Science Courses |
| HSMC | Humanities, Social Sciences and Management Courses |
| PCC | Professional Core Courses |
| PEC | Professional Elective Courses |
| OEC | Open Elective Courses |
| MC | Mandatory Courses |

**i. Course level coding scheme:** Three-digit number used as suffix with the Course Codefor identifying the level of the course. Digit at hundred's place signifies the year in which course is offered. e.g.

101, 102, 103, ……etc., for $1^{st}$ year.
201, 202, 203, ……etc., for $2^{nd}$ year.
301, 302, 303, ……etc., for $3^{rd}$ year.
401, 402, 403, ……etc., for $4^{th}$ year.

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# B.Tech. Materials Science and Technology

## Semester-Wise Structure

| Sl. | Category | Code | Course Title | L | T | P | Total Hr | Credits |
|---|---|---|---|---|---|---|---|---|
| 1. | BSC | BSC 101 (PHYS 105) | Physics | 2 | 1 | 0 | 3 | 3 |
| 2. | BSC | BSC 102 (PHYS 102) | Physics Lab | 0 | 0 | 4 | 4 | 2 |
| 3. | BSC | BSC 103 (**MATHE 111**) | Mathematics - I | ~~2~~3 | 1 | 0 | 4 | ~~3~~4 |
| 4. | BSC | BSC 104 | Biology for Engineers | 2 | 0 | 2 | 4 | 3 |
| 5. | ESC | ESC 101 | Basic Electronics Engineering | 2 | 1 | 2 | 5 | 4 |
| 6. | ESC | ESC 102 | Engineering Graphics & Design | 2 | 1 | 2 | 5 | 4 |
| 7. | HSMC | HSMC 101 | Communicative English | 2 | 0 | 2 | 4 | 3 |
| 8. | MC | MC 102 | Sports & Yoga (or) NSS/NCC | 0 | 0 | 2 | 2 | 0 |
| | | | **Total** | | | | **~~3~~031** | **~~2~~223** |

**SEMESTER 2**

| Sl. | Category | Code | Course Title | L | T | P | Total Hr | Credits |
|---|---|---|---|---|---|---|---|---|
| 1. | BSC | BSC 105 | Engineering Chemistry | 2 | 1 | 0 | 3 | 3 |
| 2. | BSC | BSC 106 | Engineering Chemistry Lab | 0 | 0 | 4 | 4 | 2 |
| 3. | BSC | BSC 107 (**MATHE 121**) | Mathematics - II | ~~2~~3 | 1 | 0 | 4 | ~~3~~4 |
| 4. | ESC | ESC 103 | Basic Electrical Engineering | 2 | 1 | 2 | 5 | 4 |
| 5. | ESC | ESC 104 | Programming for Problem Solving | 2 | 1 | 2 | 5 | 4 |
| 6. | ESC | ESC 105 | Workshop/Manufacturing Practices | 2 | 1 | 2 | 5 | 4 |
| 7. | HSMC | HSMC 102 | Universal Human Values –II | 2 | 1 | 0 | 3 | 3 |
| 8. | ESC | ESC 106 | Design Thinking & Idea Lab | 0 | 0 | 2 | 2 | 2 |
| | | | **Total** | | | | **~~3~~031** | **~~2~~526** |

**SEMESTER 3**

| Sl. | Category | Code | Course Title | L | T | P | Total Hr | Credits |
|---|---|---|---|---|---|---|---|---|
| 1. | BSC | BSC 208 **(MATHE 133)** | Mathematics – III | ~~2~~3 | 1 | 0 | 4 | ~~3~~4 |
| 2 | ESC | ESC 207 | Engineering Mechanics | 2 | 1 | 0 | 3 | 3 |
| 3. | ESC | ESC 208 | Applied Thermodynamics | 2 | 1 | 0 | 3 | 3 |
| 4. | MC | MC 202 | Environmental Science | 2 | 0 | 0 | 2 | 0 |
| 5. | PCC | PCC-MST 201 | Physics and Chemistry of Materials | 3 | 1 | 0 | 4 | 4 |
| 6 | PCC | PCC-MST 202 | Solid and Fluid Mechanics | 3 | 0 | 2 | 5 | 4 |
| 7. | PCC | PCC -MST 203 | Materials Testing Lab | 0 | 0 | 4 | 4 | 2 |

| | | | | |
|---|---|---|---|---|
| | | **Total** | **~~24~~25** | **~~19~~20** |

**SEMESTER 4**

| Sl. | Category | Code | Course Title | L | T | P | Total Hr | Credits |
|---|---|---|---|---|---|---|---|---|
| 1. | PCC | PCC-MST 204 | Phase Transformation and Phase Equilibrium in Materials | 3 | 0 | 2 | 5 | 4 |
| 2. | PCC | PCC-MST 205 | Diffusion and Heat Treatment of Materials | 3 | 0 | 2 | 5 | 4 |
| 3. | PCC | PCC-MST 206 | Ceramic and Glass Materials | 3 | 0 | 2 | 5 | 4 |
| 4. | PCC | PCC-MST 207 | Fundamentals Of Materials Processing | 3 | 0 | 0 | 3 | 3 |
| 5. | PCC | PCC-MST 208 | Materials Processing Lab | 0 | 0 | 4 | 4 | 2 |
| 6. | PEC | PEC –MST 201 | Professional Elective-I | 2 | 1 | 2 | 5 | 4 |
| | | | | | | **Total** | **27** | **21** |

**SEMESTER 5**

| **Sl.** | **Category** | **Code** | **Course Title** | **L** | **T** | **P** | **Total Hr** | **Credits** |
|---|---|---|---|---|---|---|---|---|
| 1 | PCC | PCC-MST 309 | Materials Selection and Design | 3 | 0 | 0 | 3 | 3 |
| 2 | PCC | PCC-MST 310 | Materials for Electrical, Electronics, Magnetic and Optical Technology | 3 | 0 | 2 | 5 | 4 |
| 3 | PCC | PCC-MST 311 | Polymer Science and Technology | 3 | 0 | 0 | 3 | 3 |
| 4 | PCC | PCC-MST 312 | Composite Materials | 3 | 0 | 0 | 3 | 3 |
| 5 | PCC | PCC-MST 313 | Characterization of Materials | 3 | 0 | 0 | 3 | 3 |
| 6 | PCC | PCC-MST 314 | Semiconductor Devices Lab | 0 | 0 | 4 | 4 | 2 |
| 7 | HSMC | HSMC 303 | Industrial Psychology | 3 | 0 | 0 | 3 | 3 |
| | | | | | | **Total** | **24** | **21** |

**SEMESTER 6**

| Sl. | Category | Code | Course Title | L | T | P | Total Hr | Credits |
|---|---|---|---|---|---|---|---|---|
| 1 | PCC | PCC-MST 315 | Fundamentals of Nanomaterials | 3 | 0 | 0 | 3 | 3 |
| 2 | PCC | PCC-MST 316 | Synthesis, Characterization of Nanomaterials and Device Fabrication | 3 | 0 | 2 | 5 | 4 |
| 3 | PCC | PCC-MST 317 | Corrosion Science and Engineering | 3 | 0 | 2 | 5 | 4 |
| 4 | PCC | PCC-MST 318 | Biomaterials | 3 | 0 | 0 | 3 | 3 |
| 5 | PCC | PCC-MST 319 | Materials Synthesis and Characterization Lab | 0 | 0 | 4 | 4 | 2 |
| 6 | HSMC | HSMC 304 | Project Management | 2 | 1 | 0 | 3 | 3 |
| 7 | PROJ | PROJ-MST 301 | Mini Project | 0 | 0 | 4 | 4 | 2 |
| | | | | | | **Total** | **27** | **21** |

**SEMESTER 7**

| Sl. | Category | Code | Course Title | L | T | P | Total Hr | Credits |
|---|---|---|---|---|---|---|---|---|
| 1. | PEC | PEC -MST 4xx | Professional Elective-II | 3 | 0 | 2 | 5 | 4 |
| 2. | PEC | PEC -MST 4xx | Professional Elective-III | 3 | 0 | 2 | 5 | 4 |
| 3. | OEC | OEC - xxx 4xx | Open Elective -I | 3 | 0 | 0 | 3 | 3 |
| 4. | OEC | OEC- xxx 4xx | Open Elective-II | 3 | 0 | 0 | 3 | 3 |
| 5. | PROJ | PROJ-MST 402 | Minor Project | 0 | 0 | 10 | 10 | 5 |
| 6. | SEM | PROJ-MST 403 | Seminar | 1 | 0 | 0 | 1 | 1 |
| | | | | | | **Total** | **27** | **20** |

**SEMESTER 8**

| Sl. | Category | Code | Course Title | L | T | P | Total H | Credits |
|---|---|---|---|---|---|---|---|---|
| 1. | OEC | OEC - xxx 4xx | Open Elective-III (SWAYAM/NPTEL/MOOC) | 2 | 1 | 0 | 3 | 3 |
| 2. | PROJ | PROJ-MST 404 | Major Project | 0 | 0 | 16 | 16 | 8 |
| | | | | | | **Total** | **19** | **11** |

**SEMESTER-WISE CREDIT SPLIT UP**

| Semester | No. of Credits |
|---|---|
| 1 | 22 |
| 2 | 25 |
| 3 | 19 |
| 4 | 21 |
| 5 | 21 |
| 6 | 21 |
| 7 | 20 |
| 8 | 11 |
| Total | 160 |

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# Syllabus (Semester Wise)

## for

## B.Tech. (Materials Science and Technology)

# SEMESTER 1

| S.No | Category | Code | Course Title | L | T | P | Total Hr | Credits |
|---|---|---|---|---|---|---|---|---|
| 1. | BSC | BSC 101 (PHYS 105) | Physics | 3 | 0 | 0 | 3 | 3 |
| 2. | BSC | BSC 102 (PHYS 102) | Physics Lab | 0 | 0 | 4 | 4 | 2 |
| 3. | BSC | BSC 103 | Mathematics - I | 2 | 1 | 0 | 3 | 3 |
| 4. | BSC | BSC 104 | Biology for Engineers | 2 | 0 | 2 | 4 | 3 |
| 5. | ESC | ESC 101 | Basic Electronics Engineering | 2 | 1 | 2 | 5 | 4 |
| 6. | ESC | ESC 102 | Engineering Graphics & Design | 2 | 1 | 2 | 5 | 4 |
| 7. | HSMC | HSMC 101 | Communicative English | 2 | 0 | 2 | 4 | 3 |
| 8. | MC | MC 101 | Sports & Yoga (or) NSS/NCC | 0 | 0 | 2 | 2 | 0 |
| **Total** | | | | | | | **30** | **22** |

| **BSC 101 (PHYS 105)** | **Physics** | **3L:0T:0P** | **3 Credit** |
|---|---|---|---|

**Course Objective:**
To study the fundamental principle of electromagentics

**Unit – I: Mathematical Foundations (9 hours)**
Curvilinear coordinate systems and transformations – Three-dimensional cylindrical $(\rho,\phi,z)$ and spherical $(r,\theta,\phi)$ coordinate systems – Differential length, area, and volume elements – Unit vectors in polar systems and their relations – Converting a cartesian vector to the cylindrical and spherical systems – Gradient, divergence, and curl in cartesian, cylindrical, and spherical coordinate systems – Gauss divergence theorem – Stokes theorem of vectors and their significances – Greens theorem on the plane.

**UNIT – II: Electrostatics (9 hours)**
Defining linear, surface, and volume charge density – Electric field due to an infinitely long line charge, a sheet of charge, a ring of charge, a charged disk, an electric dipole, and other charge distributions – Derivation of Gauss's law from Coulomb's law – Calculation of electric field everywhere due to symmetric charge distributions like (i) infinite sheet of charge, (ii) uniformly charged solid sphere, (iii) uniformly charged spherical shell, (iv) solid cylinder, and similar configurations.

**UNIT – III: Linear Dielectrics (9 hours)**
Calculation of dipole moment due to an electric dipole – Discontinuity of electric field on the surface of a conductor – Linear, homogeneous, and isotropic dielectrics - Dielectric polarization – Dielectric breakdown – Electric susceptibility and permittivity – Gauss's law in the presence of linear dielectrics – Capacitors with dielectrics - Calculating the capacitance (in the presence of dielectrics) of a parallel plate capacitor, a cylindrical capacitor, a spherical capacitor
.

**Unit – IV: Circuits and Resonance (9 hours)**
Classification of differential equations as linear, nonlinear, homogeneous, inhomogeneous, and coupled equations – Distinction between initial value and boundary value problems – Method of integrating factor – Method of separation of variables – Solution of homogeneous and inhomogeneous second-order ordinary differential equations with variable coefficients – Method of undetermined coefficients – Method

of variation of parameters – Applications to electrical vibrations – Response of R, L, and C elements to a sinusoidal signal – Series and parallel AC – Series LCR resonant circuit – Parallel LCR resonant circuit – Q-factor.

**Unit – V: Magnetostatics (9 hours)**
Biot-Savart law in vector form – Ampere's circuital law – Calculation of magnetic field due to (i) infinite line current, (ii) infinite sheet of current, (iii) toroid, and similar current configurations – Non-existence of magnetic monopoles – Equivalence of current-carrying loop and a magnetic dipole – Energy stored in a magnetic field – Calculation of magnetic energy density – Lorentz force equation – Motional emf – Eddy currents – Self-induction and mutual induction – Calculation of self-inductance of (i) infinitely long solenoid, (ii) coaxial cable.

***Textbooks***
[1] Sadiku, Elements of Electromagnetics, Oxford University Press.
[2] Kraus and Carver, Electromagnetics, McGraw-Hill.
[3] Boylestad, Introductory Circuit Analysis, Prentice-Hall.

***Supplementary Readings***
[1] Halliday, Resnick Walker, Fundamentals of Physics, Wiley.
[2] Alexander and Sadiku, Fundamentals of Electric Circuits, McGraw Hill.

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| BSC 102 (PHYS 102) | Physics Lab | 0L:0T:4P | 2 Credit |
|---|---|---|---|

**Course Objectives:**
1. To impart experimental skills through laboratory experiments to verify physics concepts
2. To perform experiments on properties of matter for materials science and engineering.

## *(Any Five experiments)*
1. Study of CRO fundamentals.
2. Study of passive filter (a) waveform and (b) frequency response.
3. Study of RC circuit.
4. Study of LCR circuit.
5. Study of LC circuit.
6. Frequency response of series LCR circuit.
7. Frequency response of parallel LCR circuit.
8. Study of AC bridges.

***Text Books***
[1] H. Singh, B.Sc., Practical Physics, S. Chand.
[2] Srinivasan and Balakrishnan, A Textbook of Practical Physics. Viswanathan Publishers.

***Supplementary Reading***
[1] Samir Kumar Ghosh, A Textbook of Practical Physics, New Central Book Ltd.
[2] B. Ghosh, Advanced Practical Physics. Sreedhar Publishers.
[3] Smith E. V. Manual of Experiments in Applied Physics. Butterworth.
[4] Workshop and Flint. Advanced Practical Physics for Students, Methuen and Co.
[5] Jerrad and Neil, Theoretical and Experimental Physics.

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|---|---|---|---|
| **BSC 103 (MATHE 111)** | **Mathematics – I** | **3L:1T:0P:4 C** | **Credits 3** |

**Course Objective:**

- To comprehend the mathematical concepts of matrices, ordinary differential equations, multivariable calculus and problem-solving.

**Course Contents:**

**MODULE I LINEAR ALGEBRA(MATRICES) (12 Hrs)**

Rank of a matrix - Consistency of a system of linear equations - Characteristic equation of a matrix - Eigen values and Eigen vectors - Properties of Eigen values and Eigen vectors - Cayley-Hamiltontheorem (excluding proof)- Verification- Application (Finding Inverse and Power of a matrix)- Diagonalization of a matrix by orthogonal and similarity transformation- Quadratic form – Nature of Quadratic Form- Orthogonal reduction of quadratic form to canonical form.

**MODULE II ORDINARY DIFFERENTIAL EQUATIONS (12 Hrs)**

Differential Equations of First Order- Exact equations- Leibnitz's linear equations- Bernoulli's equation- Equations solvable for p- Clairaut's equation- Differential equations of Higher order- Linear differential equations of higher order with constant coefficients- Euler's linear equation of higher order with variable coefficients- Method of variation of parameters.

**MODULE III MULTIVARIABLE CALCULUS (DIFFERENTIATION) (12 Hrs)**

Partial differentiation- Partial derivatives of first order and higher order- Partial differentiation of implicit functions- Euler's theorem on homogeneous functions - Total derivative - Jacobian Properties - Taylor's series for functions of two variables- Maxima and minima of functions of two variables.

**MODULE IV MULTIVARIABLE CALCULUS (MULTIPLE INTEGRALS)(12 Hrs)**

Double integration (Cartesian form and Polar form)-constant limits- variable limits- over the region R- Change of variables in double integrals (Cartesian to polar)- Appli- cation of double integral- Area by double integration- Change of Order of Integration- Triple Integration (Cartesian- Spherical and Cylindrical)- constant limits- variable limits- over the region R- Application of triple integral- Volume by triple integration.

**MODULE V MULTIVARIABLE CALCULUS (VECTOR CALCULUS) (12 Hrs)**

Vector Differential Operator- Gradient - Properties - Directional derivative - Divergence and curl Properties and relations- Solenoidal and Irrotational vector fields - Line integral and Surface integrals - Integral Theorems (excluding Proof) - Green's theorem - Stoke's theorem - Gauss divergence theorem.

**Text Books:**

1. Veerarajan T., "Engineering Mathematics - I & II ", Tata McGraw-Hill, New Delhi, 2014 &; 2015.
2. Dr. M.K. Venkataraman, "Engineering Mathematics – Volume I and Volume II", The NationalPublishingCompany, Chennai 2008.

**References:**

1. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, New Delhi, 43rd Edition, 2014.
2. Bali N.P and Manish Goyal., "A Text Book of Engineering Mathematics", Laxmi Publications(P) Ltd,2011.
3. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons, New Delhi, 9thEdition, 2011
4. Ramana B.V., "Higher Engineering Mathematics", Tata McGraw-Hill, New Delhi, 2010.

**ONLINE / NPTEL Courses:**

1. Differential equations for engineers: https://nptel.ac.in/courses/111106100
2. Calculus of Several Real Variables: https://nptel.ac.in/courses/111104125
3. Engineering Mathematics - I: https://nptel.ac.in/courses/111105121
4. Matrix Analysis with Applications: https://nptel.ac.in/courses/111107112

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| BSC 104 | Biology for Engineers | 2L:0T:2P | 3 Credits |
|---|---|---|---|

**Course Objectives:**

1. Introduction to Basics of Biology which includes cell, the unit of life, Different types of cells and classification of living organisms.
2. Understanding what are biomolecules present in a cell, their structure function and their role in a living organism. Application of certain bio molecules in Industry.
3. Brief introduction to human physiology, which is essential for bioengineering field.
4. Understanding the hereditary units, that is genes and genetic materials (DNA and RNA) present in living organisms and how they replicate and pass and preserve vital information in living organisms.
5. How biology can be applied in our daily life using different technology, for production of medicines to transgenic plants and animals to designing new biotechnological products.

**UNIT-I: Introduction to Basic Biology (9 hours)**

Cell: What is a Cell, Cell theory, Cell shapes, structure of a Cell, Cell cycle chromosomes, The Plant Cell and animal Cell, protoplasm, prokaryotic and eukaryotic Cell, Plant Tissue and Animal Tissue. Brief introduction to five kingdoms of classification.

**UNIT-II: Introduction to Bio-molecules (9 hours)**

Carbohydrates, proteins, Amino acid, nucleic acid (DNA and RNA) and their types.
Enzymes and their application in Industry. Large scale production of enzymes by Fermentation.

**UNIT-III: Human Physiology (9 hours)**

Nutrition (Classes of nutrients or food substances), Digestive systems, Respiratory system (two kinds of respiration – aerobic and anaerobic) Respiratory organs, respiratory cycle. Excretory system

**UNIT-IV**: **Genes, Replication of DNA, and Introduction to recombinant DNA Technology (9 hours)**

Prokaryotic gene and Eukaryotic gene structure, gene replication, Transcription and Translation in Prokaryote and Eukaryote and synthesis of protein in Eukaryotes. Recombinant DNA technology and cloning introduction.

**UNIT-V**: **Application of Biology (9 hours)**

Brief introduction to Production of vaccines, Enzymes, antibodies, Cloning in microbes, plants and animals, Basics of biosensors, biochips, Bio fuels, and Biosensors. What is Tissue engineering? And its application, transgenic plants and animals, Bio engineering (production of artificial limbs, joints and other parts of body).

**Biology for Engineers Lab:**

**List of Experiments:**

The laboratory will offer the fundamentals of analytical techniques for biological entities like microbiology, estimation and extraction of biological by products, organic compounds. The course upon completion is expected to deliver hands on experience and understanding of analytical techniques for further career growth in biotechnology.

1. Preparation of molar, normal solutions and buffers.
2. Aseptic Techniques and Media Preparation.
3. Identification of Bacterial morphology by phase contrast Microscopy/Live and dead bacterial cells by Fluorescence Microscopy.
4. Staining Techniques (Simple and Gram staining).
5. Antibacterial assay.
6. Qualitative analysis of carbohydrates.
7. Hydrolysis of sucrose
8. Glucose Estimation
9. Lowry method for protein estimation
10. Preparation of Phosphatidylcholine from egg yolk
11. Thin layer chromatography.
12. Agarose gel electrophoresis.
13. Blood grouping
14. Fabrication of biomaterials
15. Drug release analysis of biomaterials.
16. Tensile test on different types of materials
17. Compression test on different types of materials
18. Hardness tests on different types of materials

**Course Outcomes:**

1. Define the cells, its structure and function, and Different types of cells and basis for classification of living organisms.
2. Explain about biomolecules its structure and function and their role in a living organism. How biomolecules are useful in Industry & explain about human physiology
3. Demonstrate the concept of biology and its uses in combination with different technologies for production of medicines and production of transgenic plants and animals

**Text Books:**

1. Cell and Molecular Biology-P.K.Gupta
2. Cell Biology-Verma and Agarwal
3. Cell Biology-Rastogi
4. N. A. Campbell, J. B. Reece, L. Urry, M. L. Cain and S. A. Wasserman, "Biology: A global approach", Pearson Education Ltd, 2018.
5. T Johnson, Biology for Engineers, CRC press, 2011 Molecular Biology and Biotechnology, 2nd ed. J.M. Walker and E.B. Gingold. Panima Publications. PP 434.

**Reference Books:**

1. Alberts et.al. The molecular biology of the cell, 6/e, Garland Science, 2014
2. De Robertis EDP & EMF De Robertis. 2001. Cell and Molecular biology. Lippincott Williams &Wilkins.Bombay.
3. E. E. Conn, P. K. Stumpf, G. Bruening and R. H. Doi, "Outlines of Biochemistry", John Wiley and Sons, 2009.
4. John Enderle and Joseph Bronzino Introduction to Biomedical Engineering, 3/e, 2012 Principles of Biochemistry. 2nd ed. 1993. A.L. Lehninger, D.L.Nelson.M.Cox. Paniama Publications. PP. 1090.
6. Introductory Microbiology. 1995, by Trevor Gross.
7. Molecular Biology by G. Padmanabhan, K. SivaramSastry, C. Subramanyam, 1995, Mac Millan.
8. Genetic Engineering –SandhyaMitra.
9. Molecular Biology and Biotechnology by Meyers, RA, A comprehensive Desk reference (VCH Publishers).

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| ESC 101 | Basic Electronics Engineering | 2L:1T:2P | 4 Credits |
|---|---|---|---|

**Course Objectives:**

1. To understand the language of electronics, elements and their functionality
2. Basic understanding of analog systems and their applications
3. Basic understanding of digital systems and their applications

**UNIT-I: Basic Circuits Concepts (9 hours)**

Passive components: Resistance, Inductance, Capacitance; series, parallel combinations; Kirchhoff's law: Voltage, Current; Linearity. Signal sources: Voltage and Current sources; Non-ideal sources; Representation under assumption of Linearity; controlled sources: VCVS, CCVS, VCCS, CCCS; concept of Gain, Transconductance, Transimpedance Superposition theorem, Thevenin's theorem, Norton's theorem

**UNIT-II: The Operational Amplifier and Oscillator (9 hours)**

Basic model; Virtual ground concept; Inverting Amplifier, Non-inverting Amplifier, Integrator, Differentiator, Summing Amplifier and their applications. Basic feedback theory; positive and negative feedback; concept of stability; Oscillator. Waveform generator using Op-Amp for Square Wave, Triangular Wave, Wien Bridge Oscillator for sinusoidal waveform

**UNIT-III: Communication Systems (9 hours)**

Introduction - Wired and Wireless Communication system - EMW and propagation, Antenna, Broadcasting and Communication - Internet/Intranet -Optical fiber

**UNIT-IV: Digital Electronics (9 hours)**

Number systems, Binary arithmetic - Logic gates: OR, NOT, AND, NOR, NAND, XOR, XNOR gate; Truth tables - Multiplexers, Demux, Encoder, Decoder - Logic Function Representation – Combinational circuits: SOP, POS form; K-map - Latch, flip-flop: S-R flip-flop; JK flip-flop, Master-Slave flip-flop.

**UNIT-V: Application of Electronic System (9 hours)**

Instrumentation system: Transducer, Strain Gauge, DMM, Oscilloscope - Regulated power supply - Remote control, Character Display, Clock, Counter, Measurements, Data Logging, Audio-Video system

**Course Outcome:**

The students would be able

1. To learn the basics of electronic components and concepts of circuits
2. To understand the concept and application of Operational amplifiers.
3. To learn about the wired and wireless communication systems.
4. To learn the basics of digital electronics
5. To apply the knowledge of analog and digital electronics to many systems.

**Text Books:**


1. Robert Boylestad and Louis Nashelsky, “Electronic Devices and Circuit Theory” PHI; 8th Edition.200
2. Thomas L. Floyd, “Electronic Devices” 8th Edition, Pearson Education, Inc., 2007
3. A.S. Sedra and K.C. Smith, “Microelectronic Circuits”, 6th Edition, Oxford University Press, 2006


**Reference Book:**


1. J. Millman and C.C. Halkias, Integrated Electronics: Analog and Digital Circuits and Systems, McGraw-Hill, Tokyo, 1972, ISBN: 9780070423152, 0070423156
2. H. Taub and D. Schilling, Digital Integrated Electronics, Tata McGraw Hill, New Delhi, 2008, ISBN 10: 0070857881 ISBN 13: 9780070857889.


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| ESC 102 | Engineering Graphics & Design | 2L:1T:2P | 4 Credit |
|---|---|---|---|

**Course Objectives:**

1. To learn the basic principles of engineering design and graphics its place in society.
2. To get practice on computer-aided geometric design.
3. To get a practical exposure to create engineering drawings.

**UNIT-I: Traditional Engineering Graphics (9 hours)**

Principles of engineering graphics; orthographic projection; descriptive geometry; drawing principles; isometric projection; surface development; perspective; reading a drawing; sectional views; dimensioning & tolerances; true length, angle; intersection, shortest distance.

**UNIT-II: Computer Graphics (9 hours)**

Engineering graphics software; -spatial transformations; orthographic projections; model viewing; co-ordinate systems; multi-view projection; exploded assembly; model viewing; animation; spatial manipulation; surface modelling; solid modelling; introduction to building information modelling (BIM).

**UNIT-III: Introduction to Engineering Drawing (9 hours)**

Principles of engineering graphics and their significance, usage of drawing instruments, lettering, conic sections including the rectangular hyperbola (general method only); cycloid, epicycloid, hypocycloid and involute; scales – plain, diagonal and vernier scales;

**UNIT-IV: Projections (9 hours)**

Orthographic projections: principles of orthographic projections-conventions - projections of points and lines inclined to both planes; projections of planes inclined planes - auxiliary planes; projections of regular solids: those inclined to both the planes- auxiliary views; draw simple annotation, dimensioning and scale. floor plans that include: windows, doors, and fixtures such as wc, bath, sink, shower, etc.

**UNIT-V: Sectioning of Solids, Isometric Projections (9 hours)**

Sectioning of solids: Section planes perpendicular to one plane and parallel or inclined to other plane. Isometric projections: Isometric scale, drawing of isometric projections from given orthographic views.

**Engineering Graphics & Design Lab**

List of Experiments

1. Lines, lettering and dimensioning.
2. Geometrical Constructions.
3. Orthographic projections.
4. Projections of points and straight lines
5. Projections of planes.
6. Projections of solids.
7. Section of solids.
8. Isometric Projections.

**Course outcome:**

Students will be able to:

4. Introduce engineering design and its place in society.
5. Expose to the visual aspects of engineering design.
6. Expose to engineering graphics standards.
7. Expose to solid modeling.
8. Expose to computer-aided geometric design.
9. Expose to creating working drawings.
10. Expose to engineering communication.

**Text Books:**


1. N. D. Bhatt, Engineering Drawing, Charotar Publishing House, 46th Edition, 2003.
2. K. V. Nataraajan, A text book of Engineering Graphic, Dhanalakshmi Publishers, Chennai, 2006.
3. K. Venugopal and V. Prabhu Raja, Engineering Graphics, New Age International (P) Ltd, 2008.
4. Dhananjay A. Jolhe, Engineering Drawing with an Introduction to Autocad, Mc GrawHill Education, 2017.


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| **HSMC 101** | **Communicative English** | **2L:0T:2P** | **Credit 3** |

**Course Objective:**

**1.** To develop competence in English for effective communication for academic needs.
2. To get familiarity in basic writing skills necessary for engineering and social needs.
3. To impart basic skills necessary for English speaking ability.

**UNIT-I: Vocabulary Building (9 hours)**

The concept of Word Formation, Root words from foreign languages and their use in English, Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives, Synonyms, antonyms, and standard abbreviations.

**UNIT-II: Basic Writing Skills (9 hours)**

Sentence Structures, Use of phrases and clauses in sentences, Importance of proper punctuation, creating coherence, Organizing principles of paragraphs in documents, Techniques for writing precisely.

**UNIT-III: Identifying Common Errors in Writing (9 hours)**

Subject-verb agreement, Noun-pronoun agreement, Misplaced modifiers, Articles, Prepositions, Redundancies, Clichés.

**UNIT-IV: Nature and Style of Sensible Writing (9 hours)**

Describing, Defining, Classifying, providing examples or evidence, Writing introduction and conclusion.

**UNIT-V: Writing Practices and Oral Communication (9 hours)**

Comprehension, Précis Writing, Essay Writing. Listening Comprehension, Pronunciation, Intonation, Stress and Rhythm, Common Everyday Situations: Conversations and Dialogues, Communication at Workplace, Interviews, Formal Presentations

**English Lab**

**List of Practicals:**

1. How to introduce oneself?
2. Know your friend
3. Introduction to Phonemic symbols
4. Articulation of sounds in English with proper manner
5. Practice and exercises on articulation of sounds
6. Read Pronunciations/transcriptions from the dictionary
7. Practice and exercises on pronunciations of words
8. Introduction to stress and intonation
9. Rapid reading sessions
10. Extempore
11. Group discussion
12. Participating in a debate
13. Presentation techniques
14. Interview techniques

**Course Outcome:**

Students will be able to:

1. The student will acquire basic proficiency in English including reading and listening comprehension, writing and speaking skills.

**Text Books:**


1. AICTE's Prescribed Textbook: English (with Lab Manual) ISBN: 978-93-91505-097
2. Effective Communication Skills. Kul Bhushan Kumar, Khanna Book Publishing, 2022.
3. Practical English Usage. Michael Swan. OUP. 1995.


**Reference Books:**

1. Remedial English Grammar. F.T. Wood. Macmillan.2007
2. On Writing Well. William Zinsser. Harper Resource Book. 2001
3. Study Writing. Liz Hamp-Lyons and Ben Heasly. Cambridge University Press. 2006.
4. Communication Skills. Sanjay Kumar and PushpLata. Oxford University Press. 2011.
5. Exercises in Spoken English. Parts. I-III. CIEFL, Hyderabad. Oxford University Press.

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| MC 102 | Sports/Yoga or NSS/NCC | 0L:0T:2P | 0 Credit |
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**Course Objective:**

1. To impart the importance of Sports and Yoga to keep healthy minds and body
2. To develop activities for Yoga, physical education, health and fitness.
3. To advice about sports medicine and prevention of injury for better health

**UNIT-I: Introduction to Physical Education**

Physical Education- Meaning, definition, aims, Objectives and Changing trends. Meaning, importance and components of Physical Fitness & Wellness, Preventing Health Threats through Lifestyle Change, and Positive Lifestyle. Ancient & Modern Olympics (Summer & Winter), Olympic Symbols, Ideals, Objectives & Values, Awards and Honours in the field of Sports in India (Dronacharya Award, Arjuna Award, Dhayanchand Award, Rajiv Gandhi Khel Ratna Award etc.).

**UNIT-II: Kinesiology, Biomechanics & Sports**

Meaning & Importance of Kinesiology & Biomechanics in Physical Edu. & Sports, Newton's Law of Motion & its application in sports, Friction and its effects in Sports. Concept of Postures and Causes of Bad Posture. Training, warming up and limbering down, Skill, Technique & Style, Meaning and Objectives of Planning.

**UNIT-III: Psychology & Sports**

Definition & Importance of Psychology in Physical Edu. & Sports, Define & Differentiate Between Growth & Development, Adolescent Problems & Their Management, Emotion: Concept, Type & Controlling of emotions, Meaning, Concept & Types of Aggressions in Sports. Psychological benefits of exercise. Anxiety & Fear and its effects on Sports Performance. Motivation, its type & techniques. Understanding Stress & Coping Strategies.

**UNIT-IV: Yoga and Lifestyle**

Meaning & Importance of Yoga, Elements of Yoga, Introduction - Asanas, Pranayama, Meditation & Yogic Kriyas, Yoga for concentration & related Asanas (Sukhasana; Tadasana; Padmasana & Shashankasana), Relaxation Techniques for improving concentration - Yog-nidra. Asanas as preventive measures, asanas for hypertension, obesity, back pain, diabetes, asthma etc.

**UNIT-V: Doping and sports medicine:** Meaning and Concept of Doping, Prohibited Substances & Methods, Side Effects of Prohibited Substances. Sports Medicine: First Aid – Definition, Aims & Objectives.Sports injuries: Classification, Causes & Prevention. Management of Injuries: Soft Tissue Injuries and Bone & Joint Injuries

**Course outcome:**

4. To make the students understand the importance of sound health and fitness principles as they relate to better health.
5. To expose the students to a variety of physical and yogic activities aimed at stimulating their continued inquiry about Yoga, physical education, health and fitness.

6. To create a safe, progressive, methodical and efficient activity-based plan to enhance improvement and minimize risk of injury.
7. To develop among students an appreciation of physical activity as a lifetime pursuit and a means to better health.

**Text Books:**

1. Modern Trends and Physical Education by Prof. Ajmer Singh.
2. Light on Yoga by B.K.S. Iyengar.
3. Health and Physical Education – NCERT (11th and 12th Classes)

***NSS/NCC: Standard.***

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# SEMESTER 2

| S.No. | Category | Code | Course Title | L | T | P | Total Hr | Credits |
|---|---|---|---|---|---|---|---|---|
| 1. | BSC | BSC 105 | Engineering Chemistry | 2 | 1 | 0 | 3 | 3 |
| 2. | BSC | BSC 106 | Engineering Chemistry Lab | 0 | 0 | 4 | 4 | 2 |
| 3. | BSC | BSC 107 (**MATHE 121**) | Mathematics - II | 3 | 1 | 0 | 4 | ~~3~~4 |
| 4. | ESC | ESC 103 | Basic Electrical Engineering | 2 | 1 | 2 | 5 | 4 |
| 5. | ESC | ESC 104 | Programming for Problem Solving | 2 | 1 | 2 | 5 | 4 |
| 6. | ESC | ESC 105 | Workshop/Manufacturing Practices | 2 | 1 | 2 | 5 | 4 |
| 7. | HSMC | HSMC 102 | Universal Human Values –II | 2 | 1 | 0 | 3 | 3 |
| 8. | HSC | ESC 106 | Design Thinking & Idea Lab | 0 | 0 | 2 | 2 | 2 |
| **Total** | | | | | | | **~~3~~031** | **~~2~~526** |

| BSC 105 | Engineering Chemistry | 2L:1T:0P | 3 Credits |
|---|---|---|---|

**Course Objectives:**

1. To introduce basic concepts of atomic structure, chemical bonding and molecular orbitals
2. To provide a brief outline on Electrochemistry and Corrosion
3. To explain the basic concepts of organic chemistry, fuels, and polymers
4. To educate about water technology, hardness evaluation, and techniques for water softening

**UNIT-I: Fundamental concepts of atomic structure and chemical bonding (9 hours)**

Introduction, atomic structure and interatomic bonding, molecular orbitals of diatomic molecules, classifications of materials, band theory of solids, liquid crystal, and its applications, and point defects in solids. Structure and applications of graphite and fullerenes. Concepts of nanomaterials and their application in emerging trends.

**UNIT-II: Chemical thermodynamics, equilibrium, and kinetics (9 hours)**

Enthalpy and free energy changes in chemical reactions; relevance of cp and cv in gas phase reactions, chemical potential; heat capacity of solids, absolute entropy and third law of thermodynamics, Maxwell relations, Chemical potential, Equilibrium conditions for closed systems, Phase and reaction equilibria, Phase rule, Real gas, and real solution. Rate of reversible, consecutive, and parallel reactions, steady state approximation, chain reactions, enzyme-catalyzed homogeneous and heterogeneous surface-catalyzed chemical reactions, and photochemical kinetics.

**UNIT-III: Electrochemistry and Corrosion (9 hours)**

Electrochemical cells and EMF, Applications of EMF, concentration cell with and without transference. Dry corrosion and wet corrosion, mechanisms, types of corrosion, Differential metal corrosion, differential aeration corrosion, intergranular, Passivity, Pitting, Polarization - Chemical conversion coatings and organic coatings- Paints, enamels.

**UNIT-IV: Organic chemistry, Fuels, and Polymers (9 hours)**

Hydrocarbons (Alkane, Alkene, Alkyne) structure, stereochemistry, physical and chemical properties, chemical reactivity, separation. Classification of fuels, analysis of coal, and determination

of calorific value (Bomb calorimeter and Dulong's methods). Basic concepts of polymer-blend and composites, conducting, and biodegradable polymers. Preparation and application of some industrially essential polymers (BunaS, Buna-N, Neoprene, Nylon-6, nylon-6,6, and Terylene). General methods of synthesis of organometallic compounds (Grignard reagent) and their applications.

**UNIT-V: Water Technology (9 hours)**

Introduction, water analysis: i. Hardness-determination by EDTA method-numerical problems, ii. Alkalinity-determination by double indicator method-numerical problems, iii. Determination of dissolved oxygen by Winkler's method and iv. Determination of chemical oxygen demand - numerical problems. Boiler scales-formation and ill effects, prevention of scales by external method (hot lime-soda process). Desalination by electrodialysis.

**Course outcome:**

By the end of the course students would be able to:

1. Understand the fundamental concepts of atomic structure, chemical bonding, and molecular orbitals, and apply them to classify materials and comprehend band theory in solids.
2. Analyze chemical thermodynamics, equilibrium conditions, and reaction kinetics, enabling them to calculate enthalpy, free energy changes, and rate constants for various chemical processes.
3. Demonstrate knowledge of electrochemical cells, EMF, and concentration cells, along with the ability to identify corrosion mechanisms, types, and protective measures.
4. Gain insights into basic concepts of organic chemistry, fuels, and polymers, including hydrocarbon properties, polymer synthesis, and the analysis of coal and calorific value.
5. Grasp water technology principles, including hardness evaluation, different types of hardness, and techniques for water softening.

**Text Books:**


1. Physical Chemistry by G.W. Castellan (Addison Wesley Publishing Company).
2. ATKINS' Physical Chemistry by Peter Atkins, Julio de Paula (Oxford press).
3. Organic Chemistry (Volume 1) by I. L. Finar (Richard Clay and Company Ltd.)
4. Dara, S.S.; A Textbook of Engineering Chemistry (Tenth edition); S. Chand, 2003


**Reference Books:**


1. Principle of Physical Chemistry by Puri, Sharma, Pathania (Vishal Publication)
2. Physical Chemistry by S. Glasstone
3. Polymer Chemistry by Fre W., Billmeyer
4. Engineering Chemistry: Wiley


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| BSC 106 | Engineering Chemistry Lab | 0L:0T:4P | 2 Credits |
|---|---|---|---|

**Course Objectives:**

To impart scientific approach and to familiarize with the experiments in chemistry relevant for research projects in higher Studies.

**LIST OF EXPERIMENTS: (A minimum of 10 among the following experiments)**

**Section A: Inorganic Chemistry**

1. Titration with $KMnO_4$
   (i) Estimation of oxalic acid
   (ii) Estimation of Mohr's salt

(iii) Estimation of water of crystallization in Mohr's salt.

2. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
3. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.
4. Complexometric titrations using disodium salt of EDTA
   (i) Estimation of $Mg^{2+}$, $Zn^{2+}$
   (ii) Estimation of $Ca^{2+}$ by substitution method
   (iii) Estimation of Calcium content in milk.

**Section B: Organic Chemistry**

1. Purification of organic compound by crystallisation (from water and alcohol) and distillation.
2. Criteria of purity: Determination of M.P./B.P.
3. Separation of mixtures by chromatography: Measure the Rf value in each case (combination of two compounds to be given)
   (i) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by radial/ascending paper chromatography.
   (ii) Identify and separate the sugars present in the given mixture by radial/ascending paper chromatography

**Section C: Physical Chemistry**

1. Perform the following potentiometric titrations:
   (i) Strong acid *vs*. strong base
   (ii) Weak acid *vs.* strong base
   (iii) Dibasic acid *vs*. strong base
   (iv) Potassium dichromate *vs.* Mohr's salt.
2. Determination of cell constant
3. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
4. pH metric titration of
   (i) Strong acid with strong base
   (ii) Weak acid with strong base
   (iii) Determination of dissociation constant of a weak acid.
5. Perform the following conductometric titrations:
   (i) Strong acid *vs.* strong base
   (ii) Weak acid *vs.* strong base.
6. Gravimetric analysis to determine the quantity of an analyte based on the mass of a solid

**Course outcomes**:

After the completion of the course the students will be able to

1. Gain knowledge of and experience with several quantitative chemical analysis techniques to develop experimental abilities that may be used to a variety of analyses.
2. Gain practical experience using TLC to identify pharmaceuticals and develop abilities necessary to synthesise organic polymers.
3. Acquire the ability to understand, explain and use instrumental techniques for chemical analysis.
4. Accurately plan, conduct, and record scientific experiments, as well as analyse and interpret the findings.
5. Participate in ongoing learning, work as a team member, and communicate clearly. Recognise how chemistry tackles issues related to society, the economy, and the environment as well as why it is a necessary component of the curriculum.

**Text Books:**

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C.(1989),Vogel's Textbook of Quantitative Chemical Analysis, 5th Edn., John Wiley and Sons Inc.
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012),Vogel's Textbook of Practical Organic Chemistry, Pearson.
3. Mann, F.G.; Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.

**Reference Books:**

1. Khosla, B.D.; Garg, V.C.;Gulati, A.(2015), Senior Practical Physical Chemistry, R. Chand & Co.
2. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P.( 2003), Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York.
3. Kapoor, K.L. (2019), A Textbook of Physical Chemistry, Vol.7, 1st Edition, McGraw Hill Education
4. Dr. J. N. Gurtu and Amit Gurtu, Advanced Physical Chemistry Experiments

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| BSC 107 (MATHE 121) | Mathematics – II | 3L:1T:0P | 4 Credits |
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**Course Objective:**

• *To formulate and solve partial differential equations, Laplace, Fourier transforms within the engineering domain.*

**Course Contents:**

**MODULE I PARTIAL DIFFERENTIAL EQUATIONS (12 Hrs)**

Formation of partial differential equations, Solutions of standard types of first order partial differential equations, Lagrange s linear equation, Linear partial differential equations of second and higher order with constant coefficients of both homogeneous and non-homogeneous types.

**MODULE II LAPLACE TRANSFORM (12 Hrs)**

Existence conditions, Transforms of elementary functions , Properties, Transform of unit step function and unitimpulse function , Transforms of derivatives and integrals , Transforms of Periodic Functions , Initial and final value theorems.

**MODULE III INVERSE LAPLACE TRANSFORM (12 Hrs)**

Inverse Laplace Transforms Properties, Convolution theorem, Application - Solution of ordinary differential equations with constant coefficients - Solution of simultaneous ordinary differential equations.

**MODULE IV FOURIER TRANSFORM (12 Hrs)**

Fourier Integral theorem (statement only) , Fourier transform and its inverse, Properties: Fourier sine and cosine transforms, Properties, Convolution and Parseval s identity.

**MODULE V FOURIER SERIES (12 Hrs)**

Dirichlet s conditions , Expansion of periodic functions into Fourier series- Change of interval, Half-range Fourier series, Root mean square value - Parseval s theorem on Fourier coefficients, Harmonic analysis.

**Text Books:**

1. Grewal B.S, "Higher Engineering Mathematics", Khanna Publishers, New Delhi, 43rd Edition, 2015.
2. Veerarajan T, "Transforms and Partial Differential Equations", Tata McGraw-Hill, New Delhi, 2012.

**References:**


1. Bali N.P and Manish Goyal., "A Text Book of Engineering Mathematics", Laxmi Publications(P) Ltd,2011.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons, New Delhi, 9th Edition,2011.
3. Ramana B.V., "Higher Engineering Mathematics", Tata McGraw-Hill, New Delhi, 2010.


**ONLINE / NPTEL Courses:**

1. Laplace Transform: https://nptel.ac.in/courses/111106139
2. Partial Differential Equations: https://nptel.ac.in/courses/111101153
3. Advanced Engineering Mathematics: https://nptel.ac.in/courses/111107119

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| ESC 103 | Basic Electrical Engineering | 2L:1T:2P | 4 Credits |
|---|---|---|---|

**Course Objectives:**

1. This course aims to provide basic understanding of DC circuit analysis and network theorems
2. The course gives a comprehensive exposure on Three phase AC Circuits
3. To provide knowledge on Single Phase Transformer about principle of operation, construction, emf equation, equivalent circuit, power losses, efficiency
4. To teach the principle of operation of DC Machines, Single Phase and Three Phase Induction Motor, Three Phase Synchronous Machines.

**UNIT-I: DC Circuit Analysis and Network Theorems (9 hours)**

Circuit concepts and concept of network, Active and passive elements, voltage and current sources, concept of linearity and linear network, unilateral and bilateral elements, R L and C as linear elements, source transformation, Kirchoff's Law: loop and nodal methods of analysis, star delta transformation, network theorems: Thevenin's theorem, Norton's theorem, maximum power transfer theorem.

**UNIT-II: Steady State Analysis of Single Phase AC Circuits (9 hours)**

AC fundamentals: Sinusoidal, square and triangular waveforms-average and effective value, form the peak factors, concept of phasors, phasors representation of sinusoidally varying voltage and current, analysis of series-parallel RLC circuits. Apparent, active and reactive powers, power factor, causes and problems of low power factor, power factor improvement, resonance in series and parallel circuits, bandwidth and quality factors.

**UNIT-III: Three phase AC Circuits (9 hours)**

Three phase system: Its necessity and advantages, meaning of phase sequence, star and delta connections, balanced supply and balanced load, line and phase voltage/current relation, three phase power measurements. **Measurement instruments:** Types of instruments: construction and working principle of PMMC and MI type voltmeter and ammeters, single phase dynamometer type wattmeter and induction type energy meter, use of shunts and multipliers.

**UNIT-IV: Introduction of Power System (9 hours)**

General layout of electrical power system and function of its elements, standard transmission and distribution voltages, concept of grid. **Magnetic circuit:** Concepts, analogy between electric and magnetic circuit, magnetic circuits with DC and AC excitation, magnetic leakage, BH curve, hysteresis and eddy current losses, magnetic circuit calculation, mutual coupling. **Single Phase Transformer,** Principle of operation, construction, emf equation, equivalent circuit, power losses, efficiency, Introduction to auto transformers.

**UNIT-V: Principle of Electromechanical Energy Conversion (9 hours)**

DC Machines: Types, emf equation of generator and torque equation of motor, characteristics and applications of DC motors. Three Phase Induction Motor: Type, principle of operation, slip-torque Characteristics, applications. Single Phase Induction Motor: Principle of operation and introduction to methods of starting, applications. Three Phase Synchronous Machines: Principle of operation of alternator and synchronous motor, applications.

**Electrical Engineering Lab:**

List of Experiments:

1. Verification of Thevenin's Theorem.
2. Verification of Superposition Theorem.
3. Verification of Maximum Power Transfer Theorem.
4. To study V-I characteristics of diode.
5. To study the input & output characteristics of BJT in CE configuration.
6. To study the full wave rectifier circuit with &without filter and determine the ripple factor.
7. To study the phenomenon of resonance in series RLC circuit.
8. Determination of losses in single-phase transformer by OCT and SCT.
9. To calibrate a single phase induction type energy meter.
10. To study the running and reversing of a three phase SCIM.
11. Study of OP Amp based inverting and non-inverting amplifier.

**Course Outcomes:**

1. Analyses basic DC and AC electric circuits.
2. Explain the working principles of transformers and electrical machines.
3. Explain the concepts of electric power transmission and distribution of power.
4. Classify and compare different types of Electrical machines
5. Understand the wiring methods, electricity billing, and working principles of circuit protective devices and personal safety measures

**Text Books:**


1. V.Deltoro, “Principle of Electrical Engg.” PHI.
2. M.A Mallick, Dr. I. Ashraf, “Fundamental of Electrical Engg,” Word Press, Lucknow.
3. A. Hussain, “Basic Electrical Engg” Dhanpat Rai & sons.
4. I J Nagrath,“Basic Electrical Engg” ,TMH


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| ESC 104 | Programming for Problem Solving | 2L:1T:2P | 4 Credit |
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**Course Objective:**
To educate students on the basics of Python Programming, Python Data Structures, Object-Oriented Programming, Visualization and File Handling, Scientific Computing

**UNIT-I: Basics of Python**

Getting Started with Python Programming - Running code in the interactive shell, Editing, Saving, and Running a script. Using editors - Anaconda, colab. Basic coding skills - Working with data types, Numeric data types and Character sets, Keywords, Variables and Assignment statements, Operators, Expressions, Working with numeric data, Type conversions, Comments in the program, Input Processing, and Output, Formatting output. How Python works. Detecting and correcting syntax errors. Using built-in functions and modules in the math module. Control statements - Selection structure -if-else, if-elif-else. Iteration structure - for, while. Testing the control statements. Lazy evaluation.

**UNIT-II: Functions and Python Data Structures**

Functions - Hiding redundancy and complexity, Arguments and return values, Variable scopes and parameter passing, Named arguments, Main function, Working with recursion, Lambda functions. Strings - String function. Lists - Basic list Operations and functions, List of lists, Slicing, Searching and sorting lists, List comprehension. Work with tuples. Sets. Dictionaries -Dictionary functions, dictionary literals, adding and removing keys, accessing and replacing values, traversing dictionaries, reverse lookup.

**UNIT-III: Object-Oriented Programming**

Design with classes - Objects and Classes, Methods, Instance Variables, Constructors, Accessors and Mutators. Structuring classes with Inheritance and Polymorphism. Abstract Classes. Exceptions - Handle a single exception, Handle multiple exceptions.

**UNIT-IV: Visualization and File Handling**

Plotting - An Interactive Session with PyPlot, Basic Plotting, Logarithmic Plots, More Advanced Graphical Output, Plots with multiple axes, Mathematics and Greek symbols, The Structure of matplotlib, Contour and Vector Field Plots. File Processing - The os and sys modules, Introduction to file I/O, Reading and writing text files, Working with CSV files.

**UNIT-V: Scientific Computing**

Linear Algebra, Solving Nonlinear Equations, Numerical Integration, Solving ODEs. Data Manipulation and Analysis – Pandas: Reading Data from Files Using Pandas, Data Structures: Series and Data Frame, Extracting Information from a Data Frame, Grouping and Aggregation.

**At least 08 experiments should be performed from the following list:**

1. Run code in the interactive shell, edit, save, and run a script. Explore Anaconda and Colab environments

2. Implement if-else, if-elseif-else, for, and while statements. Experiment with lazy evaluation using different scenarios
3. Create functions with different parameter types, use recursion to solve problems. Explore lambda functions.
4. Perform basic operations on strings and lists. Work with tuples, sets, and dictionaries. Use list comprehensions
5. Implement classes, methods, instance variables, and constructors, and explore inheritance. Apply polymorphism and handle exceptions
6. Plot basic graphs, logarithmic plots, multiple axes plots, and contour plots. Use mathematical symbols in plots
7. Use the os and sys modules, read and write text files, and process CSV files
8. Perform linear algebra operations, solve nonlinear equations, and integrate numerically. Solve ordinary differential equations (ODEs).
9. Read data from files, create Pandas Series and Data Frames, extract information, and perform grouping and aggregation
10. Define a project related to energy systems, use Python to analyze and visualize data, implement OOP principles, and present findings

**Course outcome:**

Students will be able to:

1. To provide learners with insight into Python programming
2. Develop programming skills to solve engineering problems
3. Learn programming environments, important instructions, data representations,
4. Intermediate level features, Object Oriented Programming, and file data processing of Python.
5. Lays the foundation for scientific computing, develops web applications,
6. Machine Learning and Artificial Intelligence-based applications and tools, Data Science and Data Visualization applications.

**Text Books:**


1. Kenneth A Lambert., Fundamentals of Python: First Programs, 2/e, Cengage Publishing, 2016
2. David J. Pine, Introduction to Python for Science and Engineering, CRC Press, 2021


**Reference Books:**


1. Wes McKinney, Python for Data Analysis, 2/e, Shroff / O'Reilly Publishers, 2017
3. Allen B. Downey, Think Python: How to Think Like a Computer Scientist, 2/e, Schroff, 2016
4. Michael Urban and Joel Murach, Python Programming, Shroff/Murach, 2016
5. David M.Baezly, Python Essential Reference. Addison-Wesley Professional; 4/e, 2009.
6. Charles Severance. Python for Informatics: Exploring Information,
7. http://swcarpentry.github.io/python-novice-gapminder/Computer Programming for Engineers Lab


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| ESC 105 | Workshop/Manufacturing Practices | 2L:1T: 2P | 4 Credits |
|---|---|---|---|

**Course Objectives**

1. Workshop practice is the backbone of the real industrial environment, which helps develop and enhance the technical hand skills required by technicians working in various engineering industries and workshops.
2. Irrespective of the branch, the use of workshop practices in day-to-day industrial and domestic life helps dissolve the problems.

3. To use hand tools and machinery in Carpentry, welding shop, Foundry, Fitting shop and Sheet Metal work.
4. To provide knowledge on various manufacturing methods and CNC machining
5. To provide knowledge on basic electrical and electronics circuits design
6. To manufacture engineering products or prototypes and workshop Practices

**(A minimum of 10 among the following experiments)**

**Unit – I**

**Introduction to the Workshop:** Workshop layout. Importance of various sections/shops of the workshop. Types of jobs done in each shop. General safety rules and work procedures in the workshop.

**Fittings:** Sketch, specification and applications of fitting work holding tools-bench vise, V-block with clamp and C-clamp. Sketch, specification, material, applications and methods of using fitting marking and measuring tools-marking table, surface plate, angle plate, universal scribing block, try-square, scriber, divider, centre punch, letter punch, calipers, vernier caliper, etc. Types, sketches, specifications, materials, applications, and methods of using fitting cutting tools hacksaw, chisels, twist drills, taps, files, dies. Types, sketch, specification, material, applications and methods of using of fitting finishing tools-files, reamers. Sketch, specification and applications of miscellaneous tools-hammer, spanners, screw drivers sliding screw wrench. Demonstration of various fitting operations such as chipping, filing, scraping, grinding, sawing, marking, drilling, and tapping. Preparation of simple and male- female joints. Safety precautions.

**Tin Smithy:** Concept and conversions of SWG and other gauges in use.. Use of wire gauge. Types of sheet metal joints and applications. Types, sketches, specifications, materials, applications, and methods of using tin smithy tools-hammers, stakes, scissors/snips, etc. Demonstration of various tin smithy tools and sheet metal operations such as shearing, bending and joining. Preparation of tin smithy job. Safety precautions.

**Unit – II**

**Carpentry:** Types, sketch, specification, material, applications and methods of using of carpentry tools-saws, planner, chisels, hammers, pallet, marking gauge, vice, try square, rule, etc. Types of woods and their applications. Types of carpentry hardwares and their uses. Demonstration of carpentry operations such as marking, sawing, planning, chiseling, grooving, boring, joining, etc. Preparation of wooden joints. Safety precautions.

**Pipe Fitting:** Types, specification, material and applications of pipes. Types, specification, material and applications of pipe fittings. Types, specifications, material, applications and demonstration of pipe fitting tools. Demonstration of pipe fitting operations such as marking, cutting, bending, threading, assembling, dismantling, etc. Types and application of various spanners such as flat, fix, ring, box, adjustable, etc. Preparation of pipe fitting jobs. Safety precautions.

**Unit - III**

**Metal Joining:** Types, specification, material and applications of arc welding transformers. Types, specification, material and applications of arc welding accessories and consumables. Demonstration of metal joining operations- arc welding, soldering and brazing. Show effect of current and speed. Also demonstrate various welding positions. Demonstrate gas cutting operation. Preparation of metal joints. Safety precautions.

**Unit - IV**

**Manufacturing Methods-** Introduction to casting, forming, machining, joining, advanced manufacturing methods, CNC machining, Additive manufacturing, Plastic moulding, glass cutting

**Unit - V**

**Electrical:** Study of various electrical symbols and tools. Study of electrical components. One-way and two-way control. Lamp is controlled from three different places, including living room wiring. Godown wiring. Hospitals' room wiring, fan wiring, tube light wiring, and volt ammeter method.
**Electronics:** PN Junction diode characteristics A) Forward bias B) Reverse bias, Zener diode characteristics and Zener as voltage Regulator, Full Wave Rectifier with & without filters, Input and output characteristics of BJT in CE Configuration, Input and output characteristics of FE in CS Configuration, Common Emitter Amplifier Characteristics, Common Base Amplifier Characteristics, Common Source amplifier Characteristics, Measurement of h-parameters of transistor in CB, CE, CC configurations, Switching characteristics of a transistor, SCR Characteristics. Types of Clippers at different reference voltages, Types of Clampers at different reference voltages, The steady state output waveform of clampers for a square wave input

**Course Outcomes**
Understand the appropriate tools, materials, and instruments required for specific operations in the workshop.
Apply techniques to perform basic operations with hand tools and power tools such as a center lathe machine and drilling machine using the given job drawing.
Understand the figures of the hand tools used in fitting, carpentry, foundry, welding shop and machine tools such as lathe machine and drilling machine.
Understand a report related to hand tools and machine tools description referring to library books and laboratory manuals.
Understand report of procedures followed for a given task in fitting, carpentry, foundry, sheet metals, welding and machine shops.
Understand reports of procedures followed for a given task in various manufacturing processes.
Understand the report of procedures followed for a given task in basic electrical and electronics circuit design.
Apply safety consciousness and show teamwork.

**Text Books**

1. Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., "Elements of Workshop Technology", Vol. I 2008 and Vol. II 2010, Media promoters and publishers private limited, Mumbai.
2. Kalpakjian S. And Steven S. Schmid, "Manufacturing Engineering and Technology", 4th edition, Pearson Education India Edition, 2002.
3. Rao P.N., "Manufacturing Technology", Vol. I and Vol. II, Tata McGrawHill House, 2017.


**References**

1. Gowri P. Hariharan and A. Suresh Babu,"Manufacturing Technology – I" Pearson Education, 2008.
2. Roy A. Lindberg, "Processes and Materials of Manufacture", 4th edition, Prentice Hall India, 1998.


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| HSMC 102 | Universal Human Values – II | 2L:1T:0P | 3 Credits |
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**Course Objective:**
1. Understand the essentials of human values and skills, self-exploration, happiness and prosperity.
2. Evaluate coexistence of the "I" with the body.
3. Identify and evaluate the role of harmony in family, society and universal order.
4. Understand and associate the holistic perception of harmony at all levels of existence.
5. Develop appropriate management patterns to create harmony in professional and personal lives.

**UNIT-I: Introduction (9 hours)**

Need, Basic Guidelines, Content and Process for Value Education Purpose and motivation for the course, recapitulation from Universal Human Values-I Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and experiential Validation as the process for self-exploration - Continuous Happiness and Prosperity- A look at basic Human Aspirations Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario - Method to fulfil the above human aspirations: understanding and living in harmony at various levels.

**UNIT-II: Understanding Harmony in the Human Being (9 hours)**

Harmony in Myself! Understanding human being as a co-existence of the sentient 'I' and the material 'Body' Understanding the needs of Self ('I') and 'Body' - happiness and physical facility Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer) Understanding the characteristics and activities of 'I' and harmony in 'I' - Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail - Programs to ensure Sanyam and Health.

**UNIT-III: Understanding Harmony in the Family and Society (9 hours)**

Harmony in Human-Human Relationship- Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship - Understanding the meaning of Trust; Difference between intention and competence Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals

**UNIT-IV: Understanding Harmony in the Nature and Existence (9 hours)**

Whole existence as Coexistence - Understanding the harmony in the Nature -Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self-regulation in nature - Understanding Existence as Co-existence of mutually interacting units in all-pervasive space - Holistic perception of harmony at all levels of existence.

**UNIT-V: Implications of the above Holistic Understanding of Harmony on Professional Ethics (9 hours)**

Natural acceptance of human values, Definitiveness of Ethical Human Conduct Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order -Competence in professional ethics: a. Ability to utilize the professional competence for augmenting universal human order b. Ability to identify the scope and characteristics of people friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for above production systems. -Case studies of typical holistic technologies, management models and production systems-Strategy for transition from the present state to Universal Human Order: a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers b. At the level of society: as mutually enriching institutions and organizations. Sum up.

**Course outcome:**

Upon completion of this course, the students will be able to

1. Demonstrate the necessity of relationship with family, society and nature. Familiarize with the challenges ahead and proposed solutions.
2. Formulate and design human cyber security policies, plans and procedures for organizations.
3. Apply standard security countermeasure tools to sustain human relationships and nature.es.

4. Recognize the necessity of human values and relationship.
5. Demonstrate the learning in their real life.

**Text books**

1. P.R Gaur, R Asthana, G.P Bagaria, Human Values and Professional Ethics (2nd revised edition) Excel Books, New Delhi, 2019
2. A Nagaraj, Jeevan Vidya: Ek Parichaya, Jeevan Vidya Prakashan, Amarkantak, 1999.

**Reference Books:**

1. N Tripathi, Human Values, New Age Intl. Publishers, New Delhi, 2004.
2. Lawrence, C. (2016). Cyber security for Dummies, John Wiley & Sons Inc., 2nd Edition, pp.213--432.
3. AICTE STUDENT INDUCTION PROGRAM HANDBOOK-https://fdp-si.aicteindia.
4. org/download/Guidelines/G012%20SIP%20Hand%20Book%20v2.pdf

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| ESC 106 | Design Thinking & Idea Lab | 1L:0T:2P | 2 Credits |
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**Course Objectives:**

Students will be able to:

1. Analyze emotional experience and Inspect emotional expressions to better understand users while designing innovative products.
2. Develop new ways of creative thinking and learn the innovation cycle of Design Thinking process for developing innovative products.
3. Propose real-time innovative engineering product designs and Choose appropriate frameworks, strategies, techniques during prototype development.

**UNIT-I : Emotions and Basics of Design Thinking (9 hours)**

Understanding Emotions: Experience & Expression, Assessing Empathy, Application with Peers, Definition of Design Thinking, Need for Design Thinking, Objective of Design Thinking, Concepts & Brainstorming, Stages of Design Thinking Process (explain with examples) –Empathize, Define, Ideate, Prototype, Test.

**UNIT-II: Problem Fixing and Process of Product Design (9 hours)**

Understanding Creative thinking process, Understanding Problem Solving, Testing Creative Problem Solving, Process of Engineering Product Design, Design Thinking Approach, Stages of Product Design, Examples of best product designs and functions, Assignment – Engineering Product Design.

**UNIT-III: Design Thinking & Customer Centricity (9 hours)**

Practical Examples of Customer Challenges, Use of Design Thinking to Enhance Customer Experience, Parameters of Product experience, Alignment of Customer Expectations with Product Design.

**UNIT-IV: Electronic component familiarization (9 hours)**

understanding electronic system design flow. Schematic design and PCB layout and Gerber creation using EagleCAD. Documentation using Doxygen, Google Docs, and Overleaf. Version control tools - GIT and GitHub. Basic 2D and 3D designing using CAD tools such as FreeCAD, Sketchup, Prusa Slicer, FlatCAM, Inkspace, OpenBSP and VeriCUT. **Basic hand tools:** Tape measure, combination

square, Vernier calliper, hammers, fasteners, wrenches, pliers, saws, tube cutter, chisels, vice and clamps, tapping and threading. Adhesives Introduction to Power tools: Power saws, band saw, jigsaw, angle grinder, belt sander, bench grinder, rotary tools. Various types of drill bits.

**UNIT-V: Mechanical cutting processes (9 hours)**

3-axis CNC routing, basic turning, milling, drilling and grinding operations, Laser cutting, Laser engraving etc. Basic welding and brazing and other joining techniques for assembly. Concept of Lab aboard a Box. 3D printing and prototyping technology – 3D printing using FDM, SLS and SLA. Basics of 3D scanning, point cloud data generation for reverse engineering. Prototyping using subtractive cutting processes. 2D and 3D Structures for prototype building using Laser cutter and CNC routers. Basics of IPR and patents; Accessing and utilizing patent information in IDEA Lab

**Laboratory Activities:**

1. Schematic and PCB layout design of a suitable circuit, fabrication and testing of the circuit.
2. Machining of 3D geometry on soft material such as soft wood or modelling wax.
3. 3D scanning of computer mouse geometry surface. 3D printing of scanned geometry using FDM or SLA printer.
4. 2D profile cutting of press fit box/casing in acrylic (3 or 6 mm thickness)/cardboard, MDF (2 mm) board using laser cutter & engraver.
5. 2D profile cutting on plywood /MDF (6-12 mm) for press fit designs.
6. Familiarity and use of welding equipment.
7. Familiarity and use of normal and wood lathe.
8. Embedded programming using Arduino and/or Raspberry Pi.
9. Design and implementation of a capstone project involving embedded hardware, software and machined or 3D printed enclosure.

**Course outcome:**

1. To learn all the skills associated with the tools and inventory associated with the IDEA Lab.
2. Learn useful mechanical and electronic fabrication processes.
3. Learn necessary skills to build useful and standalone system/ project with enclosures.
4. Learn necessary skills to create print and electronic documentation for the system/project

**Text books:**

**Design Thinking**

1. Karmic Design Thinking by Prof. Bala Ramadurai,
2. Design: Creation of Artifacts in Society by Prof. Karl Ulrich, U. Penn
3. Change by Design by Tim Brown.

**Idea Lab**

1. The Big Book of Maker Skills: Tools & Techniques for Building Great Tech Projects. Chris Hackett. Weldon Owen; 2018. ISBN-13: 978-1681884325.
2. The Total Inventors Manual (Popular Science): Transform Your Idea into a Top-Selling Product. Sean Michael Ragan (Author). Weldon Owen; 2017. ISBN-13: 978-1681881584.
3. Make: Tools: How They Work and How to Use Them. Platt, Charles. Shroff/Maker Media. 2018. ISBN-13: 978-9352137374
4. The Art of Electronics. 3rd edition. Paul Horowitz and Winfield Hill. Cambridge University Press. ISBN: 9780521809269
5. Practical Electronics for Inventors. 4th edition. Paul Sherz and Simon Monk. McGraw Hill. ISBN-13: 978-1259587542

**Reference Books:**

1. Encyclopedia of Electronic Components (Volume 1, 2 and 3). Charles Platt. Shroff Publishers. ISBN-13: 978-9352131945, 978-9352131952, 978-9352133703
2. Building Scientific Apparatus. 4th edition. John H. Moore, Christopher C. Davis, Michael Coplan and Sandra C. Greer. Cambridge University Press. ISBN-13: 978-0521878586
3. Programming Arduino: Getting Started with Sketches. 2nd edition. Simon Monk. McGraw Hill. ISBN-13: 978-1259641633
4. Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards.
5. Simon Monk and Duncan Amos. McGraw Hill Education. ISBN-13 : 978-1260019193.
6. Pro GIT. 2nd edition. Scott Chacon and Ben Straub. A press. ISBN-13: 978-1484200773
7. Venuvinod, PK., MA. W., Rapid Prototyping – Laser Based and Other Technologies, Kluwer, 2004.
8. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010
9. Chapman W.A.J, "Workshop Technology", Volume I, II, III, CBS Publishers and distributors, 5th Edition,2002.

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# SEMESTER 3

| S.No | Category | Code | Course Title | L | T | P | Total Hr | Credits |
|---|---|---|---|---|---|---|---|---|
| 1. | BSC | BSC 208 **(MATHE 133)** | Mathematics – III | ~~23~~ | 1 | 0 | ~~34~~ | ~~34~~ |
| 2 | ESC | ESC 207 | Engineering Mechanics | 2 | 1 | 0 | 3 | 3 |
| 3. | ESC | ESC 208 | Applied Thermodynamics | 2 | 1 | 0 | 3 | 3 |
| 4. | MC | MC 202 | Environmental Science | 2 | 0 | 0 | 2 | 0 |
| 5. | PCC | PCC-MST 201 | Physics and Chemistry of Materials | 3 | 1 | 0 | 4 | 4 |
| 6 | PCC | PCC-MST 202 | Solid and Fluid Mechanics | 3 | 1 | 0 | 4 | 4 |
| 7. | PCC | PCC -MST 203 | Materials Testing Lab | 0 | 0 | 4 | 4 | 2 |
| **Total** | | | | | | | **~~2425~~** | **~~2122~~** |

| **BSC 208 (MATHE 133)** | **Mathematics – III** | **3L:1T:0P** | **4 Credits** |
|---|---|---|---|

**Course Objectives:**

• The course aims to equip students with the ability to apply mathematical concepts to Engineering problems.

**Unit – I: Probability** **(12 hrs)**

Sample space and Events, Axioms of Probability, Conventional Probability, Bayes' Theorem, Independent Events, Random Variables, Discrete and Continuous Random Variables – Probability Mass Function – Probability Density Function – Cumulative Distribution Function – Expectation and Variance, Standard probability Distribution – Bernoulli, Binomial, Poisson, Geomtric and Normal Distributions.

**Unit – II: Statistics and applications** **(12 hrs)**

Measures of Central Tendency – Mean- Median-Mode; Measure of Dispersion – Range – Variance-Standard Deviation; Moments, Skewness and Kurtosis, Correlation and Regression – Rank Correlation

Curve Fitting by the Method of Least Square, Fitting of Straight lines, Second degree parabolas and more general curves. Test of Significance: Large sample test for single proportion, Difference of proportions, Single Mean, Difference of Means and Difference of Standard Deviations

**Unit -III - Application of PDEs** **(16 hrs)**

Second-order linear PDE and their classification, Initial and boundary conditions, D'A lembert's solution of the wave equation; Duhamel's principle for one dimensional wave equation. Heat diffusion and vibration problems, Separation of variables method to simple problems in Cartesian coordinates. The Laplacian in plane, cylindrical and spherical polar coordinates, solutions with Bessel functions and Legendre functions. One dimensional diffusion equation and its solution by separation of variables.

**Unit IV - Numerical Methods** **(10 hrs)**

Numerical integration, Simpson rule, composite rules, error formulae, Solution of a system of linear equations, implementation of Gaussian elimination and Gauss- Seidel methods, Cholesky's method, Solution of a nonlinear equation, bisection and secant methods. Newton-Raphson method, rate of

convergence, solution of a system of nonlinear equations.

**Unit V - Numerical solution to ODE (10 hrs)**

Euler and Runge-Kutta methods, multistep methods, predictor-corrector methods, order of convergence, finite difference methods, numerical solutions of elliptic, parabolic, and hyperbolic partial differential equations. Eigenvalue problem, power method, QR method

**Text Book:**

1. Reena Garg, Engineering Mathematics, Khanna Book Publishing Company, 2022.
2. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering, 2012, New Age International Ltd., 6th Edition.
3. R.L. Burden and J. D. Faires, Numerical Analysis, 2012, 4th Edition, Brooks Cole.

**Reference Books:**

1. Reena Garg, Advanced Engineering Mathematics, Khanna Book Publishing Company, 2021.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
3. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
4. R. Agor, Elements of Mathematical Analysis, Khanna Publishing House, 2015.

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| ESC 207 | Engineering Mechanics | 2L:1T:0P | 3 Credits |
|---|---|---|---|

**Course Objectives:**

1. To learn about the concept of moment of forces and its application
2. To know the concepts of Equilibrium of rigid bodies

**UNIT-1: Introduction (9 hours)**

Specification of the force vector, Formation of Force Vectors, Moment of Force – Cross product – Problems, Resultant of a general force system in space, Degrees of freedom - Equilibrium Equations, Kinematics – Kinetics – De' Alembert's principle, Degree of Constraints – Free body diagrams.

**UNIT-II: Spatial Force systems (9 hours)**

Concurrent force systems - Equilibrium equations – Problems, Problems (Vector approach) – Tension Coefficient method, Problems (Tension Coefficient method), Parallel force systems - problems, Centre of Parallel force system – Problems.

**UNIT-III: Coplanar Force Systems (9 hours)**

Introduction – Equilibrium equations – All systems, Problems on Coplanar Concurrent force system, Coplanar Parallel force system, Coplanar General force system – Point of action, Method of joints, Method of sections, Method of sections, Method of members, Friction – Coulomb's laws of dry friction – Limiting friction, Problems on Wedge friction, Belt Friction-problems.

**UNIT-IV: Mechanics of Deformable Bodies (9 hours)**

Stress & Strain at a point- Normal and shear stresses, Axial deformations – Problems on prismatic shaft, tapered shaft and deformation due to self-weight, Deformation of Stepped shaft due to axial loading, Poisson's Ratio – Bulk Modulus - Problems, change in dimensions and volume. Centroid & Moment of Inertia: Centroid and M.I. – Arial – Radius of Gyration, Parallel axis– Perpendicular axis theorem – Simple Problems.

**UNIT-V: Dynamics of Particles (9 hours)**

Rectilinear Motion – Kinematics Problems, Kinetics – Problems, Work & Energy – Impulse Moment, Curvilinear Motion – Normal and tangential components.

**Course Outcomes:**

1. Determine the Equilibrium of System of Forces, Equilibrium of System of Forces.
2. Solve Equilibrium in three dimensions; Method of Sections; Method of Joints, to determine if a member is in tension or compression.
3. Apply various methods of Area moment of inertia, Moment of inertia of plane sections from first principles, Theorems of moment of inertia.
4. Determine Virtual displacements, principle of virtual work for particle and ideal system.
5. Apply various methods of Area moment of inertia, Moment of inertia of plane sections from first principles, Theorems of moment of inertia.

**Textbooks:**


1. Engineering Mechanics (In SI Units), S. Timoshenko, D.H. Young, J.V. Rao and Sukumar Pati, McGraw Hill Publishers, 2017,5th edition.
2. Vector Mechanics for Engineers - Statics and Dynamics, Ferdinand P. Beer, E. Russell Johnston Jr., et al., McGraw Hill Publishers, 2019, 12th edition.
3. Mechanics of Materials, Gere and Timoshenko, CBS Publishers, 2011, 2nd edition.


**Reference Books:**


1. Mechanics of Materials (SI edition), R. C. Hibbeler, Pearson publication, 2018.
2. Engineering Mechanics: Statics, SI Version, J. L. Meriam, L. G. Kraige, et al., Wiley India edition, 2017.
3. Engineering Mechanics: Dynamics, SI Version, J.L. Meriam, L.G. Kraige, et al., Wiley India edition, 2018.
4. Engineering Mechanics, S S Bhavikatti, New Age International Private Limited, 2021, 8th edition.


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| ESC 208 | Applied Thermodynamics | 2L:1T:0P | 3 Credits |
|---|---|---|---|

**Course Objectives:**

- To Explain in detail Basic Components of Rankine cycle. Methods to improve cycle performance. Types of Boilers with their working principles and applications.
- To Know the function of nozzles. Thermodynamic analysis of nozzles. Steam condensers and their requirement.
- To Study the different types of Turbines. Conditions for maximum efficiency. Parsons reaction turbine.
- To study the different types of gas turbines. Applications of gas turbines. Efficiency improvement methods

**Unit -I** **[9]**

**Air standard cycles:** Carnot, Otto, Diesel, Dual and Stirling cycles, p-v and T -s diagrams, description, efficiencies and mean effective pressures. Comparison of Otto and Diesel cycles.

**I.C.Engines:** Classification of IC engines, Combustion of SI engine and CI engine, Detonation and factors affecting detonation, Performance analysis of I.C Engines, Heat balance, Morse test, IC Engine fuels, Ratings and Alternate Fuels.

**Unit - II** **[9]**

**Gas power Cycles:** Gas turbine (Brayton) cycle; description and analysis. Regenerative gas turbine cycle. Intercooling and reheating in gas turbine cycles. Introduction to Jet Propulsion cycles.

**Unit - III** **[9]**

**Vapour Power Cycles:** Carnot vapour power cycle, drawbacks as a reference cycle. Simple Rankine cycle; description, T-S diagram, analysis for performance. Comparison of Carnot and Rankine cycles. Effects of pressure and temperature on Rankine cycle performance. Actual vapour power cycles. Ideal and practical regenerative Rankine cycles, open and closed feed water heaters. Reheat Rankine cycle. Characteristics of an Ideal working fluid in vapour power cycles.

**Unit - IV** **[10]**

**Refrigeration Cycles:** Vapour compression refrigeration system; description, analysis, refrigerating effect. Capacity, power required units of refrigeration, COP, Refrigerants and their desirable properties, alternate Refrigerants. Air cycle refrigeration; reversed Carnot cycle, reversed Brayton cycle, vapour absorption refrigeration system.

**Pscychrometrics and Air-conditioning Systems:**

Psychometric properties of Air, Psychometric Chart, Analyzing Air-conditioning Processes; Heating, Cooling, Dehumidification and Humidification, Evaporative Cooling. Adiabatic mixing of two moist air streams. Cooling towers.

**Unit – V** **[9]**

**Reciprocating Compressors:** Operation of a single stage reciprocating compressors. Work input through p-v diagram and steady state steady flow analysis. Effect of Clearance and Volumetric efficiency. Adiabatic, Isothermal and Mechanical efficiencies. Multi-stage compressor, saving in work, Optimal intermediate pressure, inter-cooling, minimum work for compression.
**Steam nozzles:** Flow of steam through nozzles, Shape of nozzles, effect of friction, Critical pressure ratio, Supersaturated flow.

**Course Outcomes:**

- Apply thermodynamic concepts to analyze the performance of gas power cycles.
- Apply thermodynamic concepts to analyze the performance of vapour power cycles.
- Understand combustion of fuels and performance of I C engines.
- Understand the principles and applications of refrigeration systems.
- Apply Thermodynamic concepts to determine performance parameters of refrigeration and airconditioning systems.
- Understand the working principle of Air compressors and Steam nozzles, applications, relevance of air and identify methods for performance improvement.

**TEXTBOOKS:**
1. Thermal Engineering / Rajput / Lakshmi Publications.
2. Gas Turbines / V. Ganesan / TMH.
3. Thermal Engineering /P.L. Ballaney / Khanna Publishers, NewDelhi.

**REFERENCE BOOKS:**
1. Gas Turbines and Propulsive Systems / P. Khajuria & S.P. Dubey / Dhanapatrai Pub.
2. Thermal Engineering / R.S. Khurmi & J.K. Gupta / S. Chand Pub.
3. Thermodynamics and Heat Engines / R. Yadav / Central Book Depot

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| MC 202 | Environmental Science | 2L:0T:0P | 2 Credits |
|---|---|---|---|

**Course Objectives:**
1. To introduce the concepts of environment, ecosystems and biodiversity and conservation.
2. To impart knowledge on the causes, effects and prevention measures of pollution.
3. To facilitate the understanding of global and Indian scenario of renewable and non-renewable resources, causes of their degradation and measures to preserve them.
4. To familiarize the influence of societal use of resources on the environment and introduce the legal provisions, National and International laws for environmental protection.
5. To inculcate the effect of population dynamics on human and environmental health and inform about human right, value education and role of technology in monitoring human and environmental issues.

**UNIT-I: Environment, Ecosystems and Biodiversity (14 hour)**
Definition, scope and importance of environment – need for public awareness - concept of an ecosystem – structure and function of an ecosystem – producers, consumers and decomposers – energy flow in the ecosystem – ecological succession – food chains, food webs and ecological pyramids – Introduction, types, characteristic features, structure and function of the (a) forest ecosystem (b) grassland ecosystem (c) desert ecosystem (d) aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries) – Introduction to biodiversity definition: genetic, species and ecosystem diversity – bio geographical classification of India – value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values – Biodiversity at global, national and local levels – India as a mega-diversity nation – hot-spots of biodiversity – threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts – endangered and endemic species of India – conservation of biodiversity: In-situ and ex-situ conservation of biodiversity. Field study of common plants, insects, birds Field study of simple ecosystems – pond, river, hill slopes, etc.

**UNIT-II: Environmental Pollution (8 hours)**
Definition – causes, effects and control measures of: (a) Air pollution (b) Water pollution (c) Soil pollution (d) Marine pollution (e) Noise pollution (f) Thermal pollution (g) Nuclear hazards – soil waste management: causes, effects and control measures of municipal solid wastes – role of an individual in prevention of pollution – pollution case studies – disaster management: floods, earthquake, cyclone and landslides. Field study of local polluted site – Urban / Rural / Industrial / Agricultural.

**UNIT-III: Natural Resources (10 hours)**
Forest resources: Use and over-exploitation, deforestation, case studies- timber extraction, mining, dams and their effects on forests and tribal people – Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems –

Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies – Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies – Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. case studies – Land resources: Land as a resource, land 47 degradation, man induced landslides, soil erosion and desertification – role of an individual in conservation of natural resources – Equitable use of resources for sustainable lifestyles. Field study of local area to document environmental assets – river, forest, grassland, hill, mountain.

**UNIT-IV: Social Issues And The Environment (7 hours)**

From unsustainable to sustainable development – urban problems related to energy – water conservation, rain water harvesting, watershed management – resettlement and rehabilitation of people; its problems and concerns, case studies – role of non-governmental organization-environmental ethics: Issues and possible solutions – climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, case studies. – wasteland reclamation – consumerism and waste products – environment protection act – Air (Prevention and Control of Pollution) act – Water (Prevention and control of Pollution) act – Wildlife protection act – Forest conservation act – enforcement machinery involved in environmental legislation- central and state pollution control boards- Public awareness.

**UNIT-V: Human Population And The Environment (6 hours)**

Population growth, variation among nations – population explosion – family welfare programme – environment and human health – human rights – value education – HIV / AIDS – women and child welfare – role of information technology in environment and human health – Case studies.

**Course Outcomes:**

1. To understand the functions of environment, ecosystems and biodiversity and their conservation.
2. To identify the causes, effects and environmental pollution and natural disasters and contribute to the preventive measures in the immediate society.
3. To identify and apply the understanding of renewable and non-renewable resources and contribute to the sustainable measures to preserve them for future generations.
4. To recognize different forms of energy and apply them for suitable applications in for technological advancement and societal development.
5. To demonstrate the knowledge of societal activity on the long- and short-term environmental issues and abide by the legal provisions, National and International laws and conventions in professional and personal activities and to identify and analyse effect of population dynamics on human value education, consumerism and role of technology in environmental issues.

**TEXT BOOKS:**


1. Anubha Kaushik and C. P. Kaushik's "Perspectives in Environmental Studies", 6th Edition, New Age International Publishers (2018).
2. Benny Joseph, 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi, (2016).
3. Gilbert M.Masters, 'Introduction to Environmental Engineering and Science', 2nd edition, Pearson Education (2004).


**REFERENCES:**


1. R.K. Trivedi, 'Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards', Vol. I and II, Enviro Media.
2. Cunningham, W.P. Cooper, T.H. Gorhani, 'Environmental Encyclopedia', Jaico Publ., House, Mumbai, 2001.
3. Dharmendra S. Sengar, 'Environmental law', Prentice hall of India PVT. LTD, New Delhi, 2007.

4. Rajagopalan, R, 'Environmental Studies-From Crisis to Cure', Oxford University Press (2005).
5. Erach Bharucha "Textbook of Environmental Studies for Undergraduate Courses" Orient Blackswan Pvt. Ltd. (2013).

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| PCC-MST 201 | Physics and Chemistry of Materials | 3L:1T:0P | 4 Credits |
|---|---|---|---|

**Course Objectives**

The course would enable the students

1. To learn the basics of quantum mechanics and its necessity and evolution.
2. To understand the behaviour of identical particles.
3. To have idea about atomic spectra and atomic structure based on quantum mechanics
4. To understand atoms and molecules via quantum mechanics
5. To gain knowledge in band theory of solids.

***UNIT-I: Basics of Quantum Mechanics*** ***(9 hours)***

Limitation of Mechanics at the Nanoscale – Evolution of Quantum Mechanics – Wave- particle Duality – Free particle confined to 1–D potential barrier – Infinite and Finite Square Well - Solution to Infinite Asymmetric Square Well Potential – Zero-point energy – Harmonic Oscillator, Particle in a box – 2D and 3D potential barriers, Double well and multiple well problem, Exciton, Quantum wells and quantum wires, Quantum-size-effect.

**UNIT-II: Identical Particles** **(9 hours)**

Schrodinger equation– Interchange symmetry. Systems of Identical particles (Classical and Quantum View) – Experiment on Indistinguishability– Exchange degeneracy – Summarization Postulate – Symmetric and antisymmetric wavefunctions – Comparison of Boson and Fermions - Constructing symmetric and antisymmetric functions (wave functions of two-, three-, and many-particle systems).

***UNIT-III: Atomic spectra and atomic structure*** ***(9 hours)***

The spectrum of atomic hydrogen - The energies of the transitions - Selection rules - Orbital and spin magnetic moments - Spin–orbit coupling - The fine-structure of spectra - Term symbols and spectral details - The detailed spectrum of hydrogen

***UNIT-IV: Quantum mechanics of Atoms and Molecules*** ***(9 hours)***

Hamiltonian and Wave functions for Many-particle systems –Multi electron system – the structures of Many-electron atoms - Orbital approximation – Justification - H, He, Li atomic structure –Pauli's principle – Born Oppenheimer approximation, Potential energy curve for diatomic molecule. Molecular orbital Theory – LCAO - Theory of $H_2$ molecule – $H_2^+$ - Bonding and anti-bonding orbitals – Bond Order

**UNIT-V**: **Band theory and electrical properties:** **(9 hours)**

The band theory of solids - The tight-binding approximation - Kronig-Penney model - Brillouin zones – The electrical properties of molecules – Molecular response parameters – The static electric polarizability – Bulk electrical properties - The relative permittivity and the electric Susceptibility - Polar molecules - Refractive index.

**Course Outcomes**

1. Basic theory of quantum mechanics for the application of materials will be learnt.
2. The concepts of identical particles can be used to understand the materials with many electrons.
3. Materials with many atoms and molecules can be understood.
4. Application of band theory to materials will be learnt.

5. The whole of materials can be viewed through the concepts of physics and chemistry.

**Text Book:**

1. Quantum Mechanics: Concepts and Applications, Nouredine Zettili, Wiley, New York,(2001), ISBN 0-471 48943 3.
2. Peter Atkins and Ronald Friedman, MOLECULAR QUANTUM MECHANICS, 4the Edn. Oxford University Press, 2005, ISBN 0-19-927498-3

**References:**

1. Quantum Mechanics, Vol I and Vol II, Claude Cohen-Tannaoudji, Bernard Diu, Franck Laloe, John Wiley & Sons (2005).
2. Quantum mechanics, J. L. Powell and B. Craseman, Addison-Wesley (1964).

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| PCC- MST 202 | Solid and Fluid Mechanics | 3L:0T:2P | 4 Credits |
|---|---|---|---|

**Course Objectives:**

1 Gain knowledge of linear elastic properties and stress strain relations.
2 Derive and solve problems on Principal stresses developed in structures.
3 Compute the stress strain for bars, beams, shafts, and column and to apply the concept of dynamic similarity and to apply it to experimental modelling.
4 Gain knowledge of basic properties of fluids, fluid statics.
5 To apply conservation of mass, momentum and energy equation and to determine the discharge of fluid flow.

**UNIT-I: Simple Stress and Strain (9 hours)**

Introduction, Concept of Stress and Strain, Linear elasticity, Hooke's Law and Poisson's ratio. Extension / Shortening of a bar, bars with varying cross sections (step and tapering circular and rectangular), Elongation due to self-weight, Principle of super position, St. Venant's Principle.
**Simple shear stress and Shear strain. Volumetric strain:** expression for volumetric strain, Elastic Constants and relations. Stresses in Composite Section.

**UNIT-II: Compound Stresses (9 hours)**

Introduction, Concept of Plane stress, Stress tensor for plane stress, stresses on inclined sections, principal stresses and maximum shear stresses, Mohr's circle for plane stress.

**UNIT-III: Torsion of Circular Shafts (9 hours)**

Introduction. Pure torsion, assumptions, derivation of torsional equations, polar modulus, torsional rigidity / stiffness of shafts. Power transmitted by solid and hollow circular shafts.
**Elastic Stability of Columns:** Euler's theory for axially loaded elastic long columns. Derivation of Euler's load for various end conditions, limitations of Euler's theory, Rankine's formula.

**UNIT-IV: Introduction to Fluid mechanics (9 hours)**

Introduction, Properties of fluids-mass density, weight density, specific volume, specific gravity, viscosity, surface tension, capillarity, vapour pressure, compressibility and bulk modulus. Concept of continuum, types of fluids etc., pressure at a point in the static mass of fluid, variation of pressure. Pascal's law, absolute, gauge, atmospheric and vacuum pressures; pressure measurement by simple, differential manometers and mechanical gauges.
**Fluid Statics:** Total pressure and centre of pressure for horizontal plane, vertical plane surface and inclined plane surface submerged in static fluid

**UNIT-V: Fluid Kinematics** **(9 hours)**

Velocity of fluid particle, types of fluid flow, description of flow, continuity equation, Coordinate free form, acceleration of fluid particle, rotational & irrotational flow, Laplace's equation in velocity potential and Poisson's equation in stream function, flow net. **Fluid Dynamics**: Introduction. Forces acting on fluid in motion. Euler's equation of motion along a streamline. Integration of Euler's equation to obtain Bernoulli's equation, Assumptions and limitations of Bernoulli's equation. Major head loss (frictional), Introduction to Navier-Stokes equation. Application of Bernoulli's theorem such as venturi-meter, orifice meter, rectangular and triangular notch, pitot tube.

**Course outcomes:**

After completing the course, the student will be able to:

1. Gain the knowledge of properties, and stress-strain relations in linear elastic solid members and fluids. To understand the concepts of fluid statics, kinematics and dynamics.
2. Describe stress-strain equation for axial, bending and torsion loads while addressing problems in engineering.
3. Apply the concepts of fluid statics, kinematics and dynamics while addressing problems in engineering and to determine the fluid flow through open and closed channel.
4. Determine the stress & strain for simple stresses, compound stresses, shafts & columns.

**List of Lab Experiments:**

1. To perform the impact test on materials.
2. To determine the Rockwell hardness of the given test specimen
3. To determine the hardness of the equipment by Brinells hardness tester
4. To determine the rigidity modulus of the spring
5. To conduct torsion test on mild steel, aluminum or cast iron specimen to find modulus of rigidity
6. To measure the rate of flow of fluid through a pipeline
7. To calibrate a given venture meter and to study the variation of coefficient of discharge
8. To demonstrate Bernoulli's Theorem through the relationship between pressure head and velocity head etc.

**Text Books:**


1. R.C.Hibbeler, Mechanics of Materials, Pearson Education, 2016.
2. James.M.Gere, Mechanics of materials, Thomson, Eighth edition, 2013.
3. Ferdinand Beer & Russell Johston, Mechanics of materials in SI Units, 5th Ed., TATA McGraw Hill- 2003.
4. R.K Bansal, A Text Book of Fluid Mechanics and Hydraulic Machines, Laxmi Publishers, 2004.
5. Fox, Fluid Mechanics: 8th Edition, Wiley India Pvt Ltd,New Delhi, 2013
6. Yunus A. Cengel, Fluid Mechanics, TataMcGraw Hill 3rd Ed., 2014.


**Reference Books:**


1. J M Gere, Timoshenko S P, Mechanics of Materials, 2nd Edition, CBS Publishers, 2004
2. S.S. Rattan, Strength of Materials, Tata McGraw Hill, 2009.
3. S.S.Bhavikatti, Strength of Materials, Vikas publications House -1 Pvt. Ltd., 2nd Ed., 2006.
4. Egor.P. Popov, Engineering Mechanics of Solids, Pearson Edu. India, 2nd, Edition, 1998.


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| PCC- MST 203 | Materials Testing Lab | 0L:0T:4P | 2 Credits |
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**Course Objectives:**
To expose the students to testing of different materials under the action of various forces and non-destructive testing of materials.

**LIST OF EXPERIMENTS (A minimum of 10 among the following experiments)**

1. Tension test on different types of materials
2. Compression testing on different types of materials.
3. Shear test on MS specimen.
4. Creep and torsion testing on MS specimen.
5. Hardness test on different types of materials.
6. Impact tests on different types of materials
7. Bending test on steel beams
8. Nanoindentation for different materials
9. Fatigue test on mild steel
10. Tear strength measurement of different types of materials
11. Study of extensometers and strain gauges.
12. To study dynamic mechanical behaviour of polymers
13. To detect flaws in materials by ultrasonic flaw detection technique
14. To measure viscoelasticity by rheometer - time dependent behaviour, viscous and loss modulus, Newtonian non- Newtonian behaviors.
15. To test the photoelectronic properties of semiconducting materials.
16. Determination of thermal expansion of nano-ceramic material by dilatometer.
17. Specific heat and enthalpy calculation using DSC analysis.
18. Liquid penetration testing
19. Magnetic particle testing.
20. Ultrasonic testing- Defect location and wear estimation.

**Outcomes**:

- The students will have the required knowledge in the area of testing of destructive and non-destructive testing methods with their inherent merits and limitations.
- Conduct investigations of Engineering components.
- Analyze the test samples by different destructive testing methods of testing.
- Differentiate between testing and inspection.

**Text Books:**


1. Timoshenko, S.P., Strength of Materials, CBS publishers, 1988.
2. Haque, M. A.; Saif, T.; Mechanical Testing at the Micro/Nanoscale. In Springer Handbook of Experimental Solid Mechanics; Sharpe, W. N., Ed.; Springer Handbooks; Springer US: Boston, MA, 2008; pp 839–870.
3. Gere, J.M., Mechanics of Materials, Cengage Learning, 2019.
4. Brown, R.P., Handbook of Polymer Testing, Smithers Rapra Press, 1997.
5. Ray F. Egerton, Physical Principles of Electron Microscopy – An Introduction to TEM, SEM and AFM, Springer, New York, 2005, ISBN:978-0387-25800-0.


**Reference Books:**


1. Harouche, I. P. F.; Shafai, C.; Gordon, R.; Design and Simulation of a Microtweezers Using a Controlled Displacement Comb Drive. In 2006 Canadian Conference on Electrical and Computer Engineering; 2006; pp 341–343.


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# SEMESTER 4

| Sl. | Category | Code | Course Title | L | T | P | Total Hr | Credits |
|---|---|---|---|---|---|---|---|---|
| 1. | PCC | PCC-MST 204 | Phase Transformation and Phase Equilibrium in Materials | 3 | 0 | 2 | 5 | 4 |
| 2. | PCC | PCC-MST 205 | Diffusion and Heat Treatment of Materials | 3 | 0 | 2 | 5 | 4 |
| 3. | PCC | PCC-MST 206 | Ceramic and Glass Materials | 3 | 0 | 2 | 5 | 4 |
| 4. | PCC | PCC-MST 207 | Fundamentals of Materials Processing | 3 | 0 | 0 | 3 | 3 |
| 5. | PCC | PCC-MST 208 | Materials Processing Lab | 0 | 0 | 4 | 4 | 2 |
| 6. | PEC | PEC –MST 201 | Professional Elective-I | 2 | 1 | 2 | 5 | 4 |
| **Total** | | | | | | | **27** | **21** |

| PCC-MST 204 | Phase Transformation and Phase Equilibrium in Materials | 3L:0T:2P | 4 Credits |
|---|---|---|---|

**Course objectives:**

1. To provide basic knowledge on the thermodynamic aspects of phase transformation, Gibbs Free energy of formation and solid solution effects of alloys.
2. To explain the basics of phase diagrams related to isomorphous alloys and iron carbon alloy, and make the students to understand the principles that determines the microstructures.
3. To impart the concepts of heat treatments induced phase transformation of iron-carbon alloys and about the Recovery, Recrystallization and Grain growth behavior of given material.

**UNIT-I: Introduction to Thermodynamics and Phase Diagrams (9 hours)**

Phase equilibrium: Thermodynamic aspects of phase formation and phase equilibrium, Classification of phase transformations, Order of transformation, Gibbs phase rule and its applications to phase diagrams, construction and interpretation, Tie-line and Lever rule, single component phase diagrams, Solubility limit, Types of solid solution: factors governing substitutional solubility Hume-Rothery rules

**UNIT-II: Binary Phase Diagrams and Microstructure formation (9 hours)**

Isomorphous alloy systems, interpretation of phase diagrams, Microstructure evolution under equilibrium and non-equilibrium cooling conditions; Applications of tie-line and lever rules to determine phase compositions and fractions; Eutectic, Peritectic, Eutectoid and Peritectoid systems; Examples of Phase diagrams and their correlations with microstructures in common alloy systems

**UNIT-III: Iron carbon Phase diagram (9 hours)**

Iron-carbon phase diagram:, development of microstructures of hypo-eutectoid, eutectoid, and hyper-eutectoid steels; phase transformation in steel, kinetics of transformation; TTT & CCT curves: pearlitic transformation, bainitic transformation, diffusional phase transformation process, diffusion less transformation; characteristics of martensitic transformation in steels, morphology of Martensite, crystallography of martensitic transformation, martensite in non-ferrous systems, shape memory effect, examples and applications of shape memory alloys.

**UNIT-III: Precipitation Reactions (9 hours)**

Precipitation reaction – thermodynamic considerations, structure and property during ageing– sequence of ageing – formation of G-P zones and intermediate precipitates, theories of precipitation hardening – effect of time, temperature and alloy compositions – precipitation free zones, crystallographic aspects of transformation, coarsening kinetics.

**UNIT-V: Phase Transformations (9 hours)**

Thermal and thermochemical heat treatments - Annealing, Normalizing, Hardening, Tempering, Carburizing, nitriding, boriding; Recovery and recrystallization and growth: Cold working and hot working, recovery – polygonization and dislocation movements in polygonisation, recrystallisation – effect of time, temperature, strain and other variables – Mechanism of nucleation and growth, grain growth – grain growth law, geometrical collisions, preferred orientation, secondary recrystallisation. Phase Transition in Ceramics and Polymers: Phase changes in ceramics: glass transition, glass tempering, glasses, Phase change in polymers and amorphous materials.

**Course Outcomes:**

Upon completion of the course, the students will be able to

1. Acquire problem-solving skills in materials science and engineering based on concepts of metallurgical thermodynamics and kinetics.
2. Understand basic principles underlying liquid-to-solid and solid-state phase transformations, and microstructural developments in binary alloys, iron-carbon and other alloy systems.

List of Lab Experiments: (Any 5 Experiments)

1. To study and observe the microstructure of pure metals (Cu, Zn, and Fe) and continuous solid solution of Isomorphous Alloy (Cu-Ni)
2. To study and observe the microstructure of eutectic alloys: Al- Si and Pb-Sb
3. To study and observe microstructure of different wt % C and cooling rate of Steels
4. To study and observe the microstructure of peritectic (Brass: Cu-Zn and Bronze: Cu-Sn) alloys and monotectic alloys (Cu-Pb).
5. To study the phase transformation of Pb-Sn eutectic alloy using DSC.
6. Draw the cooling curves of Pb-Sn alloy with the help of DTA.
7. To study the surface hardening treatments like carburizing/Boronizing on steels
8. Measurement of Volume Fraction, Surface Area in Two-Phase and Grain Size In Single-Phase Materials

**Textbooks**


1. Phase Transformations in Metals and Alloys, D.A.Porter, K.E.Easterling, M.Y.Sherif, CRC Press, 3rd edition, 2009.
2. Introduction To Physical Metallurgy, S.H.Avner, Tata McGraw Hill Publications, 1997
3. Phase Diagrams In Metallurgy, F.Rhines, McGraw-Hill, 1956
4. Phase Transformations in Materials, Jena, A.K., and Chaturvedi, M., Prentice-Hall, 1993.
5. Phase Transitions in Materials by Brent Fultz. ISBN: 9781107067240.
6. Materials Science and Engineering- William D. Callister, 6th edition, John – Wiley


**Reference Books:**


1. Physical Metallurgy Handbook, Anil Sinha, McGraw-Hill Professional; 1st edition, 2002.
2. Physical Metallurgy Principles, Reed Hill. R. E. Affiliated East West Press, New Delhi, 1992.
3. Phase Transformation in Materials, Romesh C. Sharma, CBS Publishers, New Delhi, 2002.
4. Alloy Phase Equilibira, Allan Prince, Elsevier Publishing Company, 1966

5. Phase Equilibria In Materials, Shant P.Gupta, Allied Publishers, Private Limited, 2003
6. Phase Diagrams and Heterogeneous Equilibria by Bruno Predel, Michael Hoch and Monte Pool. ISBN: 9783662092767
7. Quantitative Microscopy, R.T. DeHoff and F.N.Rhines, McGraw Hill, Book Company, 1968
8. Practical Stereology; John C. Russ and Robert, T.Dehoff, Kluwer Academic, 2001

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| PCC-MST 205 | Diffusion and Heat Treatment of Materials | 3L:0T:2P | 4 Credits |
|---|---|---|---|

**Course objectives:**

1. Explain the theory of diffusion mechanisms and nucleation and growth of materials.
2. To understand the principles and importance of heat treatment of metals and alloys
3. To explain the concepts of laser heat treatments and its industrial applications
4. To explain the rapid thermal processing of semiconductors for electronic applications

**UNIT-I: Diffusion Mechanisms and Nucleation and growth (9 hours)**

Introduction to Diffusion – uphill diffusion – downhill diffusion – atomic mechanisms of diffusion; Fick's 1st and 2nd law of diffusion –Factors influencing the rate of diffusion, Kirkendall effect, Darken's equations, Experimental determination of diffusion, examples - diffusion in metals, alloys, semiconductors; problems based on diffusion; Nucleation and growth theories - homogeneous and heterogenous nucleation – nucleation rate and growth rate – overall transformation rate.

**UNIT-II: Heat Treatment of Fe-C alloys (9 hours)**

Iron-carbon equilibrium diagram, Temperature Time Transformation (TTT) and Continuous Cooling Transformation(CCT) Plots, Annealing, Normalizing, Tempering, Martempering and Austempering, Mechanism of Heat removal during Quenching, Residual stresses Induction hardening, flame hardening; Hardenability of Steels, Jominy end-quench test, effect of parameters viz: alloying elements, carbon content, austenic grain size, Thermo-Chemical Diffusion: Carburising, Nitriding, Boronising

**UNIT-III: Laser Heat Treatments (9 hours)**

Laser Material Interaction: Heating by Laser, temperature distribution, theory of heat flow equations in laser heating, Melting & solidification, Regimes of laser remelting, Evaporation & Plasma formation – its fundamentals; Brief description of the types of high power lasers in heat treatments; laser surface hardening principle and mathematical description, effects of shielding gas and laser process parameters on laser heating of materials, principle of laser cladding, laser additive manufacturing, laser texturing

**UNIT – IV: Conduction Heat Transfer in Solids (9 hours)**

Heat transfer: Fourier's law of heat conduction in solids, Conduction: heat equation in Cartesian, cylindrical and spherical coordinates –Steady one dimensional heat conduction with and without heat generation in different geometries Factors affecting thermal conductivity of solid metals and alloys; steady state and unsteady state conduction in solids - simple examples. Transient heat conduction - Systems with negligible internal resistance - Lumped heat analysis - heat flow in an infinitely thin plate (Semi infinite body) - System with finite surface and internal resistance - Chart solutions of transient heat conduction problems – Examples on heat transfer with change of phases solidification, melting problems.

**UNIT-V: Rapid Thermal processing of Semiconductors (9 hours)**

Growth of crystalline silicon semiconductors, Rapid thermal annealing of semiconductors, dopant diffusion, Thermal Oxidation and the Si/ SiO2 Interface, silicide formation, ion implantation principle and annealing of semiconductor, laser annealing of semiconductors, chemical vapor deposition.

**Course Outcomes:**

1. On completion of this course, students will be able to understand the concepts of diffusion and the conduction, convection and radiation heat transport mechanisms.
2. Understand the effect of thermal and 71hermos chemical heat treatments of steels, and its microstructural and mechanical properties.
3. Understand the importance of high power lasers in heat treatments and surface engineering of materials and the recent trends in laser additive manufacturing for industrial applications
4. Understand the rapid thermal processing of semiconductors for electronic applications.

**List of Heat Treatment Experiments**:

(Any 10 different heat treatment experiments can be performed based on the following theme)

1. To study the conventional heat treatment procedures, such as annealing, normalizing, quenching, tempering of medium carbon steel, and examine microstructure and hardness.
2. To determine the hardenability or depth of hardness of a steel rod through the application of the standard (ASTM A255) using Jominy End-Quench Test
3. To perform high power laser hardening and alloying experiments, and study the microstructure, hardness and wear properties of medium carbon and high carbon steels.
4. To study the effect of thermo-chemical diffusion experiments such as carburizing, nitriding and boriding of medium carbon steel on the microstructure and hardness.

**Textbooks**


1. Diffusion in Solids: Fundamentals, Methods, Materials, Diffusion-controlled Processes by Helmut Mehrer. ISBN: 9783540714866.
2. Kinetic Processes: Crystal Growth, Diffusion and Phase Transitions in Materials by Kenneth Jackson. ISBN: 9783527327362
3. Kothandaraman C P , “Fundamentals of heat and Mass Transfer”, second edition, New Age International Publishers, Chennai, 1997.
4. Materials Science and Engineering by William F. Smith, Tata McGraw-Hill Education.
5. Physical Metallurgy: Principles and Practice by V. Raghvan, PHI Learning.
6. Heat Treatment: Principles and Techniques by T.V. Rajan, C.P. Sharma, , PHI Learning.
7. Laser Material Processing: W.M.Steen, (Springer Verlag).
8. Rapid Thermal Processing of Semiconductors, Victor E. Borisenko , Peter J. Hesketh, Springer.


**Reference Books:**


1. Byron Bird R, W E Shawart, “Transport Phenomena”, John-Wiley & Sons Inc, 1994.
2. Engineering Physical Metallurgy, Y. Lakhtin.
3. Introduction to Physical Metallurgy, S.H.Avner.
4. Elements of Physical Metallurgy, A.G.Guy.
5. Physical Metallurgy for Engineers , Clark & Varney.
6. Semiconductor Manufacturing Handbook, Hwaiyu Geng, McGraw-Hill Education.


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| PCC- MST 206 | Ceramic and Glass Materials | 3L:0T:0P | 3 credits |
|---|---|---|---|

**Course Objectives:**

1. The course will offer the preliminary understanding of Ceramics and glasses.
2. Evaluate the behaviour and their analytical methodologies of ceramic and glasses.

**UNIT-I: Introduction (9 hours)**

Definition and scope - Oxides and non-oxides - Types - Structure - bonding - electronegativity - Pauling's rule - coordination number - factors affecting structure - Material behaviour - Electrical properties - magnetic properties - optical properties - mechanical properties - thermal properties - Industrial applications - Glasses as products - glass colouration Industry - Optics - glass screen - Ceramic insulator - Refractories - furnaces - pyrometry - Cement and concrete - Whitewares and potteries - Anticorrosion coating or paints - Pigments.

**UNIT-II: Defects, Thermodynamics and Phase Transformation (9 hours)**

Kroger Vink notations - Point, Schottky and Frenkel defects - Stoichiometric and non-stoichiometric defect reactions - Kinetic and thermodynamic - Entropy - Gibbs free energy - Theory of nucleation - Solidification - Diffusion - Glassy State - criteria for glass formation - Phase diagrams - Phase rule - Phase equilibrium - Clausius-Clapeyron equation - Phase Transformation - Phase equilibrium diagrams for one and two-component systems – its industries application

**UNIT-III: Processing and Fabrication (9 hours)**

Oxide and non-oxide powders synthesis techniques - Composites - Pre-fabrication process of ceramics and glass - Additives - Drying - Particle size reduction processes - Crushing or milling - colloids - agglomerates - Particle charge distribution - Rheology of colloidal suspensions - Fabrication techniques - Additive and subtractive manufacturing - Direct casting - solid freeform fabrication - Pressing - Extrusion - Injection moulding – Deposition or coating.

**UNIT-IV: Analytical Techniques for Ceramics and Glasses (9 hours)**

Characterization - Thermo-chemical monitor - X-ray diffraction - Vibration Bands Spectroscopy - Porosity evaluator - Morphological and mechanical analyzer - Principles of sintering and microstructure development - Weibull distribution - Weibull parameters - stable crack propagation - R-curve behaviour - Toughening mechanism - Toughening by transformation - Role of the interfacial and interphase domain in ceramics.

**UNIT-V: Advanced ceramics and glasses (9 hours)**

Electro-ceramics - Piezoelectric and electro-optic - Ceramic Magnets – 2D ceramics for energy applications- photosensitive and photochromic glasses - Bio-ceramics - Dense and porous hydroxyl apatite calcium phosphate ceramics- bioactive glasses – Bio-inert ceramics – High entropy ceramics - Ceramic for acoustic observer, thermal Barrier ceramic, EMF shielding, nuclear waste storage.

**Course Outcomes:**

Completion of this course will provide the graduates with the understanding of ceramics and glasses for their research endeavours.

**List of Experiments to conduct Laboratory**

1. Formulation of Glasses and Bioglasses
2. Analysis of Allotropic Phase Transformation in Ceramics
3. Development of Ceramic Coatings on Metals
4. Principles and methodologies in the Extrusion of Ceramics
5. Powder X-ray diffraction methodologies in the structural characterization of Ceramics

6. Vibrational spectroscopic analysis of metal oxides and glasses
7. Mechanical characterization of Dense ceramics

**Textbooks:**


1. Fundamentals of Ceramics – Barsoum
2. Introduction to Glass science- L. D. Pye
3. Solid State Chemistry and its Applications By: A. R. West, John Wiley & Sons (Asia) Pte. Ltd
4. Chemistry of Glasses - A. Paul
5. Industrial Ceramics - Singer & Singer
6. Hand book of Glass Manufacture – Vol. I & II- by Tooley
7. A book of industrial ceramics by Felix Singer
8. Ceramic Processing and Sintering- M. N. Rahaman
9. Introduction to the principles of ceramic processing- J. S. Reed
10. Chua Chee Kai, Leong Kah Fai, 3D Printing and Additive Manufacturing: Principles &Applications, 4th Edition, World Scientific, 2015


**Reference Books:**


1. Introduction to thermodynamics of materials: D.R. Gaskell
2. Introduction to Phase Equilibria in Ceramic Systems by F. A. Hummel, Marcel Dekker.
3. Phase Diagrams: Materials Science and Technology, A. M. Alper, Vol. I, II and III,
4. Phase Diagram for Ceramists by E. M. Levin, H. F. McMurdie and F. P. Hall, The American Ceramic Society, OH, USA
5. Ceramic Materials for Electronic Application – R. C. Buchanon
6. Introduction to Bio-Ceramics – L. L. Hench and J. Wilson
7. Non-Oxide Materials: Applications and Engineering by Makuteswara Srinivasan, William Rafaniello
8. Modern Magnetic materials : Principles and Applications – Robert C.oHandly
9. Ultra-High Temperature Ceramics: Materials for Extreme Environment Applications – Fahrenholtz.


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| PCC-MST 207 | Fundamentals of Material Processing | 3L:0T:0P | 3 Credits |
|---|---|---|---|

**Course Objectives:**

1. To understand the significance of materials processing in manufacturing and engineering.
2. To provide basic knowledge on different types of materials processing techniques, including casting, forming, machining, welding, and heat treatment.
3. To learn different types of materials, structures, and properties relevant to processing.

**UNIT-I: Processing of Materials (9 hours)**

Thermodynamics of solidification, pure metal solidification, Alloy Solidification: Constitutional undercooling, dendritic growth. Structure of casting and ingots, Types of casting, Heat transfer, Joining- Welding and its types, Brazing and Soldering, Microstructural mechanisms associated with metals joining operations, Powder Metallurgy, Additive manufacturing of metals.

**UNIT-II: Fabrication of Metals (9 hours)**

Fundamentals of forming operations of metals: Rolling- Analysis of rolling, hot and cold rolling, microstructural changes during rolling, rolling defects, rolling mill; Forging- open and closed die forging; lubricated and nonlubricated extrusion.; wire-drawing- die design and materials, optimal die angle, sheet metal forming bending, stretching and deep drawing, anisotropy parameter, forming limit diagram, microstructural changes, Casting of metals, Heat treatment of Steels.

**UNIT-III: Fabrication and Processing of Inorganic materials & Ceramics (9 hours)**
Powder preparations, solid state reactions, Sintering, Colloidal processing, Co-precipitation method, Sol-Gel process, Microwave assisted processing, Porous ceramics and ceramic fibres. Glass forming techniques, Fabrication and processing of Clay products, Powder pressing, Tape casting.

**UNIT-IV: Processing of Plastics (9 hours)**
Forming techniques of plastics, Fabrication of Elastomers, fibers and films. Processing of Polymers-Mixing and compounding, extrusion process, moulding processes, thermoforming, roller and blade coating, textile/fiber spinning technology, Additive manufacturing of polymers and ceramics.

**UNIT-V: Fabrication of Composites (9 hours)**
Classification of Composite material - metal matrix composite, ceramic matrix composite, polymer matrix composite. Processing of fiber-reinforced composites, Fabrication techniques: Open moulding, Resin infusion process, High volume moulding – compression moulding, Filament winding, Tube rolling.

**Course outcomes**:
After the completion of the course the students will be able to
1. Students will demonstrate a solid understanding on the principles and concepts of materials processing, including the relationship between processing methods and material properties.
2. Students will be able to identify and describe different types of materials, including metals, polymers, ceramics, and composites, and understand their properties and behaviors.
3. Students will apply thermodynamics principles to understand phase transformations, equilibrium considerations, and other thermodynamic aspects of materials processing.

**Textbooks:**

1. Flemings,M.C., (1974), Solidification Processing, Mcgraw-Hill Book Company
2. Dieter,G.E., (1986), Mechanical Metallurgy, 3rd Edition, McGraw Hill Book Company
3. Kareh, B., Fundamentals of semiconductor processing technology, 3rd Edition, 1995, Springer US.
4. Chalmers,B., (1967), Principles of Solidification, Wiley


**Reference Books:**

1. Stefanescu,D.M., (2015), Science and Engineering of Casting Solidification, 3rd edition, Springer.
2. Hosford, W.F., Caddell, R.M., (2014), Metal Forming: Mechanics and Metallurgy, 4th Edition, Cambridge University Press Online Course Material


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| PCC-MST 209 | Materials Processing Lab | 0L:0T:4P | 2 Credits |
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**Course Objectives:**
Received training in research skill and methodology for novel chemical and physical processing approaches of different materials.

**List of Experiments (A minimum of 10 among the following experiments)**
1. Processing of ceramic materials like zirconia, clay, hydroxy apatite, etc.
2. Sintering of ceramics
3. Processing of polymer materials like polyaniline, ect.

4. Casting of thermosetting resins.
5. Rubber compounding.
6. Polymer nanocomposite preparation.
7. Production of plastic products using injection moulding, extrusion and blow mouldings, etc.
8. Additive manufacturing of polymers
9. Additive manufacturing of ceramics and inorganic oxides
10. Microwave processing of materials
11. Autoclave assisted hydro-/solvothermal processing of materials
12. Ball mill (Top-down ) processing of materials
13. Microemulsion processing and LB-Film technique
14. Physical methods of thin film processing
15. Scaled -up processing using CSTR
16. Fluidized bed reactor processing
17. Heat treatment studies of metals and alloys
18. Powder processing of metals and ceramics.

**Course outcomes**:

After the completion of the course the students will be able to

1. Understanding of materials processing principles
2. Hands-on processing techniques.
3. Material formability and workability
4. Correlation of processing with material performance:

**Textbooks:**


1. Zheng Cui, Micro-Nanofabrication Technologies and Applications, Springer-Verlag, Beijing, 2005, ISBN: 9783540289227.
2. Garry P. Wiederrecht, Handbook of Nanofabrication, First Edition, Elsevier, Amsterdam, 2010, ISBN: 9780123751768.
3. Nanoparticles: Theory to Applications by Günter Schmid, 2010 WILEY-VCH Verlag GmbH & Co. KGaA, Boschstr. 12, 69469 Weinheim.
4. Prospects in Nanotechnology: Toward Molecular Manufacturing, Markus Krummenacker and James Lewis (Editors), Wiley 1995.


**Reference Books:**


1. Self-Assembled Nanostructures: Jin Z. Zhang, Zhong-lin Wang, Jun Liu, Shaowei Chen, and Gang-yu Liu, 2003 Kluwer Academic/Plenum Publishers, NY, USA


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# SEMESTER 5

| S.No | Category | Code | Course Title | L | T | P | Total Hr | Credits |
|---|---|---|---|---|---|---|---|---|
| 1 | PCC | PCC-MST 309 | Materials Selection and Design | 3 | 0 | 0 | 3 | 3 |
| 2 | PCC | PCC-MST 310 | Materials for Electrical, Electronics, Magnetic and Optical Technology | 3 | 0 | 2 | 5 | 4 |
| 3 | PCC | PCC-MST 311 | Polymer Science and Technology | 3 | 0 | 0 | 3 | 3 |
| 4 | PCC | PCC-MST 312 | Composite Materials | 3 | 0 | 0 | 3 | 3 |
| 5 | PCC | PCC-MST 313 | Characterization of Materials | 3 | 0 | 0 | 3 | 3 |
| 6 | PCC | PCC-MST 314 | Semiconductor Devices Lab | 0 | 0 | 4 | 4 | 2 |
| 7 | HSMC | HSMC 303 | Industrial Psychology | 3 | 0 | 0 | 3 | 3 |
| **Total** | | | | | | | **24** | **21** |

| PCC-MST 309 | Materials Selection and Design | 3L:0T:0P | 3 Credits |
|---|---|---|---|

**Course Objectives:**

1. To address the materials selection problems for industrial applications
2. To achieve design objectives to accomplish the manufacturing requirements
3. To select the shapes and processing technologies

**Unit-I: Design Process (9 hours)**

Classification and meaning of design - Types of design - Design tools and materials data – The relation between Function, material, shape, and process - relation of materials selection to design, general criteria for selection, performance characteristics of materials, materials selection process, design process and materials selection, material property chart, material performance indices, materials selection procedure, Structural index, economics of materials, recycling and materials selection

**Unit-II: Engineering Materials and Selection (8 hours)**

Evolution of engineering materials - families of engineering materials - definitions of material properties - material property charts - selection strategy - Attribute limits and material indices - selection procedure - Computer-aided selection - The structural index

**Unit-III: Material Properties and Design (10 hours)**

Stress - Strain diagram, design for strength, rigidity, design under static loading, stress due to torsion and bending, variable loading, stress concentration, fluctuating stress, eccentric loading – stress concentration. Design examples with shaft design and spring design

Design for brittle fracture, plane strain fracture toughness, fatigue failure, Design criteria, fatigue parameters, infinite, safe life and damage tolerance design, fatigue life prediction, corrosion resistance, forms of corrosion, corrosion prevention, Design against wear, types of wear, wear prevention, Designing with plastics, design for stiffness, Time dependent part performance

**Unit-IV: Industrial Process Design (10 hours)**

Role of Processing in Designing, classification of manufacturing processes, types of manufacturing systems, influence of material on process selection. Design for manufacturability, DFM guidelines, Design for assembly, DFA guidelines, computer methods for DFMA - Selection with multiple constraints – Designing under different conditions – surface finish, size, reliability temperature, stress and service environment etc.

**Unit-V: Selection of Material and Shape (8 hours)**

Importance of shape - Shape factors - Microscopic or micro-structural shape factors - Limits to shape efficiency - Exploring and comparing structural sections - Material indices that include shape - Co-selecting material and shape – case studies

**Course Outcomes:**

1. To provide the students a thorough systematic approach to the selection of metals, ceramics, polymers, and composites required for mechanical design
2. To familiarize the students with fabrication processes to attain the functional properties of materials
3. To enable the student to select a process capable of producing a component possessing the size, shape, properties, and cost by the design.

**Text Books:**


1. M. F. Ashby and K. Johnson, Materials and Design, Butterworth Publication, 2002
2. Michael F. Ashby, Materials Selection in Mechanical Design, 4th Edition, Butterworth-Heinemann, 2011.
3. Md Abdul Maleque, Mohd Sapuan Salit, Materials Selection and Design, Springer, 2013.


**Reference Books:**


1. Dieter George E, Engineering Design, Tata McGraw-Hill education, 1991.
2. Bhandari V B, Design of Machine Elements, 3rd edition, Tata McGraw-Hill Education, 2010
3. Charles J A and Crane F A A, Selection and Use of Engineering Materials, Elsevier, 2013
4. Mangonan P L, The Principles of Materials Selection for Engineering Design, Prentice Hall, 1999
5. ASM Handbook : Materials Selection and Design, Volume 20, Taylor and Francis,1997
6. Mahmoud M Farag, Materials and Process Selection for Engineering Design, CRC Press, 2013


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| PCC- MST 310 | Materials for Electrical, Electronic, Magnetic and Optical Technology | 3L:0T:2P | 4 Credits |
|---|---|---|---|

**Course Objectives:**

1. To introduce the fundamentals of various properties and material selection
2. To expose the properties and applications of functional materials in modern technology.
3. To familiarize the students with various concepts related various properties and their exploitation to develop the useful materials based on the structure, chemistry and the processing techniques

**Unit-I: Electrical Properties (9 hours)**

Electrical properties of metals & alloys: Classical theories of conductivity, Quantum mechanical theory of conductivity, Experimental results & their interpretations: metals, alloys, ordering & phase stability, Superconductivity: theory & experiment

Electrical properties of semiconductors: Band structure, Intrinsic & Extrinsic semiconductors, Hall effect, Compound semiconductors, Electrical properties for device applications

**Unit-II: Magnetic Properties (9 hours)**

Magnetic Properties, Basic concepts in magnetism, Classical theory of magnetic phenomena & their interpretations: Diamagnetism and Paramagnetism, Ferromagnetism, Antiferromagnetism and Ferrimagnetism, The Influence of Temperature on Magnetic Behaviour, Domains and Hysteresis, exchange of energy, magnetocrystalline energy, magnetostriction, Magnetic Anisotropy, Soft Magnetic Materials, Hard Magnetic Materials, Magnetic Storage, Superconductivity, spintronics, memory devices, multiferroic materials, Ferromagnetic shape-memory alloys & Dilute magnetic semiconductors

**Unit-III: Optical Properties (9 hours)**

Optical Properties, Introduction, Electromagnetic Radiation, Optical absorption in insulators, semiconductors and metals, Atomic and Electronic Interactions, Optical properties f metals and non-metals, Refraction, Reflection, Absorption, Transmission, Colour, Opacity and Translucency in Insulators, Applications of optical phenomena, Luminescence, Photoconductivity, Lasers, Laser generation and optics, Laser Applications in Materials Processing, Fundamentals of laser materials interactions and laser ablation, Laser materials, Optical Fibers in Communications, optical materials, liquid crystals and LCD, LED devices, NLO materials.

**Unit-IV: Thermal Properties (9 hours)**

Thermal properties-Introduction, heat capacity, thermal expansion of materials, thermal conductivity, thermal diffusivity, Emissivity, thermal stability, thermal insulation materials, Phase change materials: Types of PCMs, encapsulation of PCM, applications.

**Unit-V: Dielectric Properties (9 hours)**

Dielectric constant and polarizability - different kinds of polarization - Internal electric field in a dielectric -Clausius- Mossotti equation - dielectric in ac field - dielectric loss - ferroelectric – types and models of ferro electric transition - electrets and their applications – piezoelectric and pyroelectric materials.

**Course Outcomes:**

Upon successful completion of the course, the students will be able to

1. Learn the basics of materials used in present electrical and electronic industry.
2. Explain the behavior of thermal and optical properties of materials
3. Explain the importance of magnetic properties.
4. Realize the dielectric properties of insulators in static and alternating fields

**List of Lab Experiments:**

1. Measurement of DC conductivity of the samples
2. Measurement of AC conductivity of solids/films
3. To determine the resistivity of a semiconductor as a function of temperature and to estimate its band gap using four-probe method
4. Determination of Dielectric Constant of Solids & Liquids
5. Determination of band gap of semiconductors using optical absorption spectra
6. To study the thermal properties of solids
7. Measurement of capacitance value

**Text Books:**


1. James F Shackelford, Introduction to Materials science for Engineers, Pearson, 2015
2. Charles Kittel, Introduction to Solid State Physics, John Wiley & Sons 1991
3. Neil W. Ashcroft and N. David Mermin, Solid State Physics, Sauders College, Philadelphia, USA, 1976
4. V.Raghavan, Materials Science and Engineering: A First Course. PHI Learning, 2015.

5. S.O.Kasap. Principles of Electronic Materials and Devices. McGraw-Hill Education, 2017.

**Reference Books:**

1. R. E. Hummel, Electronic Properties of Materials, Springer, 2011
2. R. D Rawlings, et al. Materials Science. Springer, 2013.
3. William D Callister, David G. Rethwisch. Materials science and engineering. Vol. 5, John Wiley & Sons, 2011.
4. James F Shackelford, et al. CRC materials science and engineering handbook. CRC press, 2016.

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| PCC-MST 311 | Polymer Science and Technology | 3L:0T:0P | 3 Credits |
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**Course Objectives:**

1. To provide a thorough understanding of the basic concept of polymers and polymerization mechanisms
2. To learn various polymerization techniques.
3. To learn the molecular weight determination and characterization of polymers.
4. To study the conducting polymers and polymer processing.

**UNIT I: Elements of Polymer Science (9 hours)**

Some basic definitions, Classification of polymers, Different types of polymerizations like addition and condensation polymerizations; Copolymerization - Functionality, degree of polymerization, Nomenclature of polymers, Tacticity in polymers; Polymerization techniques - Emulsion, bulk, suspension and solution polymerization; Polymerization using metal catalysts and surfactants.

**UNIT II: Elements of Polymer Science (9 hours)**

Chain and step polymerization; Mechanism of ionic, radical, coordination polymerization (Ziegler-Natta catalyst); **Speciality polymers:** Synthesis of aromatic polyethers, polyacetals, polyamides, polyurethane, Bio-polymers, Bio-degradable polymers, Fire retardant polymers, Liquid crystalline polymers.

**UNIT III: Molecular weight and Characterization of polymers (9 hours)**

Number average, weight average and viscosity average of polymers. Determination of molecular weight of polymers by GPC and Viscometry methods; **Glassy solids:** Glass transition and melting temperatures and their determination - Factors affecting Tg, importance of Tg, relationship between Tm and Tg and their control; **Crystallinity in polymers**: Degree of crystallinity, factors affecting crystallinity of polymers, effect of crystallinity on the properties of polymers; Thermal analysis of polymers using DSC, TG/DTA and DMA.

**UNIT IV: Conducting Polymers (9 hours)**

Discovery – Conduction mechanism – Classification of conducting polymers: Intrinsic and extrinsic conducting polymers - Chemical and electrochemical methods for the synthesis of conducting polymers – Applications of conducting polymers in corrosion protection, electrochemical energy devices and sensors.

**UNIT V: Polymer Processing (9 hours)**

Materials for Processing of plastics: Resins, fillers, plasticizers, stabilizers, colorants and anti-oxidants, lubricants - functions and examples; Types of plastics and their uses with examples; Processing techniques: Compression moulding, injection moulding, blow moulding, film casting, and

extrusion moulding; Industrially important polymers and their processes: polyethylene, polystyrene, Nylon-6,6, Nylon -6, PET, Inorganic polymers – Silicone polymers and Polyphosphazines.

**Course Outcomes:**

On completion of the course, students should be able to

1. Understand the basic concept of polymers and the molecular weighing depth.
2. Understand the chemistry of organic and inorganic polymers.
3. Understand the polymerization mechanism kinetics and various polymerization techniques.
4. Choose an appropriate analytical method to characterize polymers.
5. Select an appropriate moulding technique to process a particular polymer.
6. Realize about the conducting polymers and their uses.

**Text books**


1. Billmeyer F. W., 2010.*"Text Book of Polymer Science"*, 3rd Ed., Gurukripa Enterprises, New Delhi, (Unit I to IV)
2. Harry R Allock, Fredeick W Lampe and James E Mark, 2005 "*Contemporary Polymer Chemistry"* 3rd Ed., Pearson Education. (Unit V)
3. G.S. Misra, 2008 *"Introductory Polymer chemistry"*, New Age International Pvt. Ltd.
4. Anil Kumar and Rakesh K. Gupta, 2003 *"Fundamentals of polymer engineering"* Tata McGraw Hill Publication Ltd., New Delhi, (revised and expanded edition).


**Reference books**


1. Gowariker V.R., Viswanathan N.V. and Jayadev Sreedhar, 2014 *"Polymer Science"*, New Age International Publishers.
2. Fried and Joel R, 2000 *"Polymer Science and Technology"*, Phi Learning Pvt. Ltd, New Delhi.
3. Mathur G.N., 2000 *"Recent Advances in Polymers and Composites"*, Allied Publishers, New Delhi, Sinha R, 2002 *"Outlines of Polymer Technology"*, Phi Learning Pvt. Ltd, New Delhi
4. Tager A, 1972 *"Physical Chemistry of Polymers"* MIR Publications,
5. Seymour R.H. and Charaher C.E., 2003 *"Polymer Chemistry"*, 6th Ed., Marcel Dekker Inc.
6. Stuart and Barbara, 2010 *"Polymer Analysis"* Wiley India, New Delhi.
7. G. Odian, 2007 *"Principles of Polymerisation"*, IV Edition, Wiley Student Edition, New Delhi,
8. M.G. Arora, M. Singh and M.S. Yadav, 2003 *"Polymer Chemistry"* II revised Edition, Anmol Publications Pvt. Ltd.


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| PCC- MST 312 | Composite materials | 3L:0T:0P | 3 Credits |
|---|---|---|---|

**Course Objectives:**

1. The course is framed to deliver the knowledge of engineering composites which will pave the way to relate the aspects of new materials and their applications.
2. Analysing the composite materials for advanced engineering applications.

**Unit-I: Introduction to Composite Materials (9 hours)**

Introduction to Composites, Need for composites, classification and characteristics of composite, Materials – fibrous composites, laminated composites, particulate composites, Nanocomposites, Maximum stress theory, Maximum strain theory, Tsai-Hill theory, Tsai, Wu tensor theory, Generalized Hooke's law, Numerical problems.

**Unit-II: Fiber Reinforced Plastic (9 hours)**

Thermosetting and thermoplastics, Glass, Carbon and Kevlar Fibers, Preparation and properties of different types of fibers, Manufacturing of fiber composites: Hand layup, Pressure bag, Vacuum Bag

and Autoclave processes, Pultrusion, Filament Winding, thermo-forming, injection moulding and blow moulding. Micromechanics and prediction of elastic constants of continuous and short fiber composites.

**Unit-III: Mechanics of a Lamina (9 hours)**

Introduction, Rule of Mixture evaluation of the four elastic moduli, Micro Mechanical Analysis of a Lamina. The Lamina's macro mechanics: Hooke's law for various materials kinds Two-dimensional link between compliance and stiffness matrix; number of elastic constants, Engineering constants - Numerical problems. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.

**Unit-IV: Metal matrix and Ceramic matrix composites: (9 hours)**

Metal Matrix Composites: Reinforcement materials, types, characteristics and selection base metals selection. Need for production MMC's and its application. Fabrication Process For MMC's: Powder metallurgy technique, liquid metallurgy technique and secondary processing, special fabrication techniques. Engineering ceramic materials – properties – advantages – limitations – Monolithic ceramics - Need for CMC – Ceramic matrix - Various types of Ceramic Matrix composites- oxide ceramics – non oxide ceramics – aluminium oxide – silicon nitride – reinforcements – particles-fibres- whiskers. Sintering - Hot pressing – Cold isostatic pressing (CIPing) – Hot isostatic pressing (HIPing)

**Unit-V: Applications of Composite materials (9 hours)**

Automobile, Aircrafts. Missiles, Space hardware, Electrical and electronics, Marine, recreational and sports equipment, future potential of composites.

**Course Outcomes:**

1. The outcome of the course will equip the engineers to relate composite materials and their applications in real time applications.

**Textbooks:**


1. Mathews F.L. and Rawlings R.D., Composite materials: Engineering and Science, Chapman and Hall, London, England, 1st edition, 1994.
2. Composite Materials: Science and Engineering, Third Edition, by Krishna K. Chawla, Springer (2013). ISBN: 978-0-387-74364-6
3. Jones, R M, *Mechanics of Composite Materials*, Scripta Book Co.
4. Agarwal, B D and Broutman, J. D, *Analysis and Performance of Fiber Composites*, New York, John Willey and Sons, 1990.
5. Mallik, P. K, *Fiber reinforced composites: materials, manufacturing and design*, New York-Marcel and Dekker, 1993 (2nd edition).


**References:**


1. Arthur, K Kaw, *Mechanics of Composite Materials*, CRC Press, 1997.
2. Reddy J N, *Mechanics of Laminated Composite Plates*, CRC Press.
3. Mallik, P. K, *Composite Engineering Hand Book*, New York, Marcel and Dekker, 1997 (2nd edition)**.**
4. T. W. Clyne, D. Hull, *An Introduction to Composite Materials*, Cambridge University Press, 2019 (3rd edition).
5. George Dvorak, *Micromechanics of Composite Materials*, Springer (2013). ISBN: 978-9400741003.


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| PCC- MST 313 | Characterization of Materials | 3L:0T:0P | 3 Credits |
|---|---|---|---|

**Course Objectives:**
To familiarize the students with the fundamental principles and common material characterization methods to determine the structure and composition of solids.

**Unit-I: Optical Spectroscopic Techniques (9 hours)**
Importance of material characterization – classification of material characterization techniques – mechanical characterization process – measurement of hardness – fracture toughness through nano indentation – adhesion test-surface profilometry – tribological studies of materials, Optical microscopic techniques.
Optical properties – magnification, numerical aperture, resolving power, depth of focus, depth of field, various illumination techniques – bright field, dark field, phase-contrast polarized light illuminations, interference microscopy – Image analysis.

**Unit-II: Surface Analysis Techniques (9 hours)**
Importance of surface characterization techniques–principle, working and applications of AFM, Surface area, pore volume measurements by B.E.T. method, Mercury porosimetry - Particle size measurement, Principle and working of SEM, STEM, TEM, imaging dark and bright field– specimen preparation techniques–merits and demerits- applications.

**Unit-III: X Ray Diffraction Techniques (9 hours)**
Characteristic X–ray spectrum-Bragg's Law–Diffraction methods-Laue method, rotating crystal method, powder method – X ray diffractometer – determination of crystal structure–lattice parameter-measurement of residual stress.

**Unit-IV: Surface Analytical Techniques (9 hours)**
Principles, working and application of DTA, TGA, TMA and DSC– UV–Visible (UV–VIS), IR & Raman spectroscopy–FTIR, NMR, X-ray fluorescence spectroscopy – EDXRF, WDXRF. Auger Electron spectroscopy, X-ray photoelectron spectroscopy – Optical emission spectroscopy

**Unit-V: Ion Beam Techniques (9 hours)**
Ion Beam Analysis: Rutherford Backscattering Spectrometry (RBS), Proton/particle Induce X-ray Emission (PIXE), Proton/particles induced Gamma-ray Emission (PIGE), Secondary Ion Mass Spectroscopy (SIMS), Electron backscatter diffraction (EBSD), Focused Ion Beam (FIB), elastic recoil detection analysis and nuclear reaction analysis. Etc.

**Course Outcomes:**
By the successful completion of this course, the student will be able to
1. Have an understanding of the basic physics, mechanisms and applications of the characterization methods commonly used in materials engineering.
2. Know the principles of metallurgical microscope, X-ray Diffractometer (XRD), scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Thermal analysis and dilatometer.
3. Perform various sample/specimen preparation techniques for XRD, SEM and TEM.
4. Determine the crystal structure, lattice parameter, surface topography using different methods.
5. Select appropriate tool to characterize the material by knowing its merits and demerits.

**Text Books:**
1. K. R. Hebbar, Basics of X-Ray Diffraction and its Applications, I.K. International Publishing House Pvt Ltd, (2007)

2. V. A. Phillips, Modern Metallographic Techniques and their Applications, John Wiley & Sons, 1st edition, (1972).
3. V. T. Cherepin and A. K. Mallic, Experimental Techniques in Physical Metallurgy, Asia Publishing Compny, (1967).

**Reference Books:**

1. B. D. Cullity, Elements of X-ray Diffraction, Prentice Hall, 3rd edition, (2001).
2. A. Mammoli, C. A. Brebbia and A. Klemm, Materials Characterisation, WIT Press, 1st edition, (2011).
3. V. Voort, Metallography: Principle and practice, ASM International, (1999).

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| PCC-MST 314 | Semiconductor Device Lab | 0L:0T:4P | 2 Credits |
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**Course Objectives:**

This course is intended to equip any students interested in electronic materials and devices with the fundamentals of semiconductor devices. The materials covered in the course begins with fundamentals and accelerates to advanced topics in semiconductor physics. The course connects circuit performance to material and device behaviour.

**A minimum of 10 experiments among the following**

- Electrical conductivity of a semiconductors intrinsic & Extrinsic Behavior for given diodes
- Hall effect, determination of Hall coefficient
- Determine the function transistor, types and their working
- Draw and construct the transistor Current components of common base (CB), Common Collector (CC), Common Emitter (CE) configuration characteristics and its graphical analysis
- Explore the transistor amplifier in CE mode for both NPN & PNP transistor, hybrid equivalent of CE, Emitter follower.
- Field Effect Transistor(FET) construction of JFEET, pinch- off voltage, Transfer and output characteristics.
- MOSFET: MOS Diode, Basic construction of MOSFET and working and I-V characteristics, enhancement and depletion mode
- Complimentary MOS (CMOS) Special Diodes
- Zener Diode - VI Characteristics – Zener diode as peak clipper, Tunneling Effect-Tunnel diode.
- Construct the PIN Diode.
- Semiconductor device fabrication process using simple oxidation
- P-N junction device fabrication by physical method and testing.
- Construct the Metal Oxide Semiconductor Field Effect Transistors (MOSFET) Circuit Design to Devices
- FET Based Gas Sensor
- Biosensing and characteristic studies by MOSFET
- Semiconductor *p-i-n* diode and surface barrier detector characteristic measurements

**Course Outcomes:**

At the end of the course, students will:

1. Learn the important concepts related to semiconductor technology.
2. Perform the analysis and design of semiconductor devices (electrostatics and current-voltage characteristics) from fundamental principles.
3. Learn how to extract device parameters by suitable experiments.
4. Engineer and innovate on device design and even construct new devices intended for special applications in circuits. There is special emphasize placed on this aspect.

5. Learn the fundamentals of circuit design and observe how device properties and device design impact circuit behavior (eg. dc and ac response, noise)
6. Extend the concepts and analysis to advanced topics such as: devices based on disordered semiconductors (eg. organic semiconductors, amorphous metal oxides), flexible and printed electronics, etc.

**Text books**:
1. Modern Physics, R.Murugeshan & Er.K.Shivaprasath, S.Chand (2015).
2. Semiconductor Device Fundamentals, Robert F. Pierret, Pearson education
3. Solid state Physics,S. O. Pillai, New age International Publishers
4. Hand Book of Electronics, Gupta and Kumar, Pragati Prakasan, Meerut

**Reference books**:
1. Physics for degree students, C L Arora and P. S. Hemme, S Chand Publications
2. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
3. Introduction to Solid State Physics, Charles Kittel, Wiley India Pvt. Ltd.
4. B. G. Streetman and S. Banerjee, Solid State Electronic Devices, 6th Edition, PHI Private Limited, 2011.
5. P. Bhattacharya, Semiconductor Optoelectronics Devices, 2nd Edition, PHI, 2009.
6. G. Massobrio and P. Antognetti, Semiconductor Device Modeling with SPICE, 2nd Edition, TMH, 2010.
7. C. C. Hu, Modern Semiconductor Devices for Integrated Circuits, Pearson Education, 2010.
8. R. S. Muller and T. I. Kamins, Device Electronics for Integrated Circuits, 3rd Edition, Wiley India, 2009.
9. S. M. Sze and K. K. Ng, Physics of Semiconductor Devices, 3rd Edition, Wiley India, 2010.
10. Y. Tsividis, Operation and Modeling of the MOS transistor, 2nd Edition, TMH, 1999.
11. S. A. Neamen and D. Biswas, Semiconductor Physics and Devices, 4th Edition, TMH, 2012.

**Web links and Video Lectures (e-Resources):**
1. https://youtu.be/k6ZxP9Yr02E
2. https://youtu.be/JA3sCmrv11M
3. https://youtu.be/mHAyQhz0ILE
4. https://youtu.be/N01BYteinzE
5. https://www.classcentral.com/course/swayam-fundamentals-of-electronic-device-fabrication-14080

**Activity Based Learning (Suggested Activities in Class)/ Practical Based learning:**
1. https://youtu.be/c0fs-sNWmMM
2. https://nptel.ac.in
3. https://swayam.gov.in
4. https://vlab.amrita.edu

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| HSMC 303 | Industrial Psychology | 3L:0T:0P | 3 Credits |
|---|---|---|---|

**Course Objectives:**
The aim of undergoing this course is to develop an awareness of the major perspectives underlying the field of Industrial Psychology and understanding for the potential Industrial Psychology has for society and organizations now and in the future.

**UNIT-I: Introduction (9 hours)**

The role of the psychologist in industry, the field of occupational Psychology: Study of behaviour in work situation and applications of Psychological principles to problems of selection, Placement, Counselling and training.

**UNIT-II**: **Design of Work Environments (9 hours)**

Human engineering and physical environment techniques of job analysis, Social environment: Group dynamics in Industry Personal psychology, Selection, training, placement, promotion, counselling, job motivations, job satisfaction. Special study of problem of fatigue, boredom and accidents.

**UNIT-III: Understanding Consumer Behavior (9 hours)**

Consumer behaviour, study of consumer preference, effects of advertising, Industrial morale: The nature and scope of engineering psychology, its application to industry.

**UNIT-IV: Work Methods (9 hours)**

Efficiency at work, the concept of efficiency, the work curve, its characteristics, the work methods; hours of work, nature of work, fatigue and boredom, rest pauses. The personal factors; age abilities, interest, job satisfaction, the working environment, noise, illumination, atmospheric conditions, increasing efficiency at work; improving the work methods, Time and motion study, its contribution and failure resistance to time and motion studies, need for allowances in time and motion study.

**UNIT-V: Work and Equipment Design (9 hours)**

Criteria in evaluation of job-related factor, job design, human factors, Engineering information, input processes, mediation processes, action processes, methods design, work space and its arrangement, human factors in job design. Accident and Safety: The human and economic costs of accidents, accident record and statistics, the causes of accidents situational and individual factors related to accident reduction.

**Course Outcomes:**

After completing this course, the student will be able to:

1. Understanding of key concepts, theoretical perspectives, and trends in industrial psychology.
2. Evaluate the problems thorough and systematic competency model.
3. Analyze the problems present in environment and design a job analysis method.
4. Create a better work environment for better performance.
5. Design a performance appraisal process and form for the human behavior.

**Text Books:**


1. Tiffin, J and McCormic E.J., Industrial Psychology, Prentice Hall, 6th Edn., 1975.
2. McCormic E.J., Human Factors Engineering and Design, McGraw Hill, 4th Edn.,1976.
3. Mair, N.R.F., Principles of Human relations
4. Gilmer, Industrial Psychology
5. Ghiselli & Brown, Personnel and Industrial Psychology. 6. Myer, Industrial Psychology.
6. Dunnete, M.D., Handbook of Industrial and Organizational Psychology.
7. Blum & Taylor, Industrial Psychology


**Reference Books:**


1. Barker, C., Pistrang, N., & Elliott, R. (2015). Research methods in Industrial psychology: An introduction for students and practitioners. John Wiley & Sons.
2. Coolican, H. (2017). Research methods and statistics in psychology. Psychology Press.
3. Hecker, Jeffrey E. and Thope, Geoffrey L. (2005). "Introduction to Industrial Psychology", Pearson Education Inc.


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# SEMESTER 6

| Sl. | Category | Code | Course Title | L | T | P | Total Hr | Credits |
|---|---|---|---|---|---|---|---|---|
| 1 | PCC | PCC-MST 315 | Fundamentals of Nanomaterials | 3 | 0 | 0 | 3 | 3 |
| 2 | PCC | PCC-MST 316 | Synthesis, Characterization of Nanomaterials and Device Fabrication | 3 | 0 | 2 | 5 | 4 |
| 3 | PCC | PCC-MST 317 | Corrosion Science and Engineering | 3 | 0 | 2 | 5 | 4 |
| 4 | PCC | PCC-MST 318 | Biomaterials | 3 | 0 | 0 | 3 | 3 |
| 5 | PCC | PCC-MST 319 | Materials Synthesis and Characterization Lab | 0 | 0 | 4 | 4 | 2 |
| 6 | HSMC | HSMC 304 | Project Management | 2 | 1 | 0 | 3 | 3 |
| 7 | PROJ | PROJ-MST 301 | Mini Project | 0 | 0 | 4 | 4 | 2 |
| **Total** | | | | | | | **27** | **21** |

| PCC-MST 315 | Fundamentals of Nanomaterials | 3L:0T:0P | 3 Credits |
|---|---|---|---|

**Course Objectives:**

To motivate the students to understand the basics in nanomaterials and make them to understand different processing methods, properties and characterization of nanomaterials for the future Engineering applications.

**Unit-I** **9 hours**

**Introduction to Nanomaterials:** Definition and scope of nanomaterials - Historical development of nanomaterials – Nanostructure and Nanoparticles: Basic concepts of nanostructures (0D, 1D, 2D, and 3D); Synthesis methods for nanoparticles (top-down and bottom-up approaches); Fabrication methods for nanowires, nanofibers and nanosheets; **Properties of Nanomaterials:** Size-dependent properties (optical, mechanical, electrical, magnetic); Quantum confinement effects and surface phenomena in nanomaterials; Thermal stability, chemical reactivity, and surface energy of nanomaterials.

**Unit II** **9 hours**

**Bonding in Nanostructures:** Atomic bonding in solids, Vander Waals interactions/Electrostatic interactions - Hydrogen bonding - Bonding in Fullerenes, Graphene, CNTs, Carbyne, and MXene; Synthesis of Graphene and CNTs, Functionalization of CNTs and Graphene; Inorganic nanotubes: Dichalcogenides, metal and metal oxides; Micro- and Mesoporous materials. Imperfections/defects in Nanocrystalline solids.

**Unit III** **9 hours**

**Metallic Nanomaterials:** Synthesis and properties of metallic nanoparticles (gold, silver, platinum, etc.);Applications of metallic nanomaterials in catalysis, sensing, and biomedical fields; Surface plasmon resonance (SPR) and optical properties of metallic nanoparticles; **Semiconductor Nanomaterials:** Semiconductor quantum dots (QDs) and their properties; Fabrication methods and applications of semiconductor nanomaterials in photonics and electronics; Bandgap engineering and

size-tunable properties of semiconductor nanomaterials; **Nanocomposites Materials:** Introduction to nanocomposites (polymer nanocomposites, ceramic nanocomposites, metal matrix nanocomposites); Preparation, properties and applications.

**Unit IV** **9 hours**

**Characterization Of Nanomaterials:** X-ray diffraction (XRD), SEM, EDAX, TEM, FTIR, UV-visible spectrophotometer, Laser Raman Spectroscopy, Differential Scanning Calorimeter (DSC), Differential Thermal Analyzer (DTA), Thermo gravimetric Analysis (TGA), X-ray Photoelectron Spectroscopy (XPS), Atomic force microscopy (AFM), BET analyzer, Nano indenter.

**Unit V** **9 hours**

**Ethical and Safety Considerations in Nanomaterials:** Environmental impact and sustainability of nanomaterials; Health and safety aspects of working with nanomaterials; Regulatory frameworks and responsible use of nanotechnology.

**Course Outcomes:**

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

1. Understand basics in nanomaterials and their classification.
2. Acquire knowledge in the synthesis routes of zero, one and two-dimensional nanomaterials.
3. Understand the advantages and limitations of various synthesis routes.
4. Acquire knowledge in characterization of nanomaterials.
5. Acquire knowledge in ethical and safety considerations of nanomaterials.

**Textbooks**


1. Carl C. Koch (ed.), "Nanostructured Materials", Processing, Properties and Potential Applications, Noyes xPublications, Norwich, New York, U.S.A.,2002.
2. Bhusan, Bharat (Ed), “Springer Handbook of Nanotechnology”, 2nd Edition, 2007.
3. Charles P. Poole Jr., Frank J. Ownes, ‘Introduction to Nanotechnology”, Wiley
4. Interscience, 2003.
5. G Timp (ed), “Nanotechnology”, AIP press/Springer, 1999.
6. Viswanathan B, 2014, “*Nano Materials*”, Narosa Publishing House Pvt Ltd.
7. G. Cao and Y. Wang, 2011, *“Nanostructures and nanomaterials: synthesis, properties and applications*”, World Scientific, 2nd edition.
8. G. Wilde, “Nanostructured Materials’, Elsevier, 2008.


**References**


1. K. Goser, P. Glosekotter and J. Dienstuhl, 2005, *“Nanoelectronics and nanosystems: from transistors to molecular and quantum devices*”, Springer.
2. M.S. Dresselhaus and G. Dresselhaus, 1996, *“Science of fullerenes and carbon nanotubes*”, Academic press.
3. J. Altmann, Routledge, 2006, *“Military Nanotechnology: Potential Applications and Preventive Arms Control*”, Taylor and Francis Group.
4. Mark Ratner and Daniel Ratner, “Nano Technology”, Pearson Education, New Delhi, 2003.
5. Bamberg, D., Grundman, M. and Ledentsov, N.N., “Quantum Dot Heterostructures”,Wiley, 1999.


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| PCC-MST 316 | Synthesis, Characterization of Nanomaterials and Devices Fabrication | 3L:0T:2P | 4 Credits |
|---|---|---|---|

**Course Objectives:**
Deals understanding at an advanced level of Physics and Chemistry for Nanotechnological applications and mainly focus on the design and development of efficient innovative nanostructured materials prepared by various methodologies and physicochemical characterization for technological applications that can facilitate widespread commercialization and it also acquired an understanding of selected areas of nanoscience and technology for various applications at the frontiers areas, beyond the undergraduate level.

**UNIT-I: Soft Chemical Processes (9 hours)**
Synthesis of Nanomaterials by Soft Chemical Methods: Chemical precipitation and co- precipitation: Metal nanocrystals synthesis by polyol, and Borohydrate reduction methods, Sol- Gel synthesis; Microemulsions synthesis, normal and reverse micelles formation, Hydrothermal, Solvothermal.

**UNIT-II: Chemical processes (9 hours)**
Synthesis methods of dimensionally modulated Inorganic nanostructured materials Thermolysis routes, Microwave assisted synthesis; Sonochemical assisted synthesis, Core-Shell nanostructure, Organic –Inorganic Hybrids, Quantum dot (QDs) synthesis. Carbon Nanotubes, (SWCNT, MWCNT), Graphene nanosheets. Photochemical synthesis, Synthesis in supercritical fluids and Electrochemical synthesis

**UNIT-III: Physical processes (9 hours)**
Fabrication of Nanomaterials by Physical Methods: Inert gas condensation, Arc discharge, RF-plasma, Plasma arc technique, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy (MBE), Chemical vapour deposition (CVD) method. Template assisted synthesis, Catalyst assisted chemical vapour deposition (CCVD).

**UNIT-IV: Biological Methods of Synthesis (9 hours)**
Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magneto tactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the nanostructured materials; synthesis process and application, Role of plants in nanoparticle synthesis.

**UNIT-V: Nanostructured materials Characterization and Device Fabrication (9 hours)**
X-ray diffraction (XRD), SEM-EDAX, TEM, Elemental mapping, FTIR, UV-Visible spectrophotometer, Nanomechanical Characterization using Nanoindentation, Thermal Analysis (TGA/DTA/DSC), X-ray Photoelectron Spectroscopy (XPS), Electrochemical Characterization measurements and its device fabrication technologies, Fuel cell, batteries, solar cells, Hydrogen electrolyser, capacitor.

**Course outcomes**:
After the completion of the course the students will be able to
1. Develop a solid understanding of the fundamental principles of nanoscience and nanotechnology, including unique properties and behaviours of nanomaterials.
2. Acquire knowledge of various synthesis methods for nanomaterials, such as chemical vapor deposition, sol-gel, physical vapor deposition, and wet chemical methods.
3. Gain proficiency in advanced characterization techniques used for nanomaterials, including electron microscopy, X-ray diffraction, spectroscopy, and atomic force microscopy.
4. Learn the principles of designing and engineering nanomaterials with specific properties, such as size, shape, and surface functionalities.

5. Develop skills in the fabrication of nanodevices, including nanosensors, nanoelectronics, and nanophotonics, using cleanroom processes and nanofabrication techniques.
6. Learn about the fabrication of nanomaterial-based devices for energy harvesting applications, including solar cells and thermoelectric generators.

**List of Experiments to be done (7 experiments selected from the list):**

1. Synthesis of LiNiMnCoO2 by co-precipitation method and its nanocoating for Lithium cell energy storage device fabrication
2. Synthesis of photoelectrocatalyst (metal oxides/sulfide) by microwave assisted hydro/solvo-thermal methods and fabrication of Photo/electrochemical hydrogen generation.
3. Preparation of Graphene by Chemical and electrochemical exfoliation method for fabrication of supercapacitors.
4. Bio-synthesis of Au, and Ag metal nanoparticles for photonics and anti-microbial studies.
5. Co-precipitation Synthesis of multi-ferrite nanoparticles and measure magnetic properties by VSM/EPR.
6. Preparation of Nanoporous material and Core –shell nanoparticles for bio-imaging.
7. Preparation of metal chalcogenide nanocrystals/quantum dots and its spectral studies.
8. Preparation of carbon dots and its optical studies.
9. Preparation of nanoscale CdS, CdSe, CdSSe semiconducting optical glasses and study its spectral properties by fabricating optical glasses as colour filters for satellite communication applications.

**Text Books:**


1. Nanochemistry: A Chemical Approach to Nanomaterials – Royal Society of Chemistry, Cambridge UK 2005.
2. Chemistry of Nanomaterials: Synthesis, properties and applications by CNR Rao et.al., Royal Society of Chemistry, Cambridge UK 2006.
3. Active Metals: Preparation, characterization, applications – A. Furstner, Ed., VCH, New York 1996.
4. Characterization of Nanophase materials – Z.L Wang (ed), Wiley-VCH, New York 2000.
5. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.
6. Nanostructured Silicon – based powders and composites – Andre P Legrand, Christiane Senemaud, Taylor and Francis, London New York 2003.


**Reference Books:**


1. Processing & properties of structural nanomaterials - Leon L. Shaw (editor)
2. Elements of X-ray Diffraction by Cullity, B. D.,, 4th Edition, Addison Wiley, 1978.
3. Electron Beam Analysis of Materials by Loretto, M. H., Chapman and Hall, 1984.
4. Vacuum Physics and Techniques by T.A. Delcher, Chapman & Hall.


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| PCC-MST 317 | Corrosion Science and Engineering | 3L:0T:2P | 4 Credits |
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**Course Objectives:**
The course provides knowledge on basics in corrosion, various types of corrosion, its kinetics, testing and protection methods.

**Unit-I: Basics in Corrosion (9 hours)**
Importance and economics of corrosion, Principles of corrosion, classification of corrosion, Nernst equation and electrode potentials of metals, EMF and galvanic series, Pourbaix diagram and its importance to iron, aluminium and magnesium metals. Electrode kinetics, Evans diagram, Exchange current density; Polarization and types of polarization. Mixed potential theory.

**Unit-II: Types of Corrosion (9 hours)**
Uniform, Pitting, Intergranular, Stress corrosion, Corrosion fatigue, Fretting corrosion, Erosion corrosion, Crevice corrosion, Hydrogen embrittlement and Dezincification – their Causes and remedial measures/control methods.

**Unit-III: Oxidation of Metals and Alloys (9 hours)**
Passivity, Electrochemical behaviour of active/passive metals, Tafel equation, Flade potential, theories of passivity, Effect of oxidising agents; High temperature corrosion, Pilling- Bedworth ratio, Ellingham diagram of oxidation, Effect of doping on the oxidation behaviour, Catastrophic oxidation; Corrosion Behaviour of Metals and Alloys; Corrosion of Ceramic materials, Concrete and Polymer materials.

**Unit-IV: Corrosion Testing and Monitoring (9 hours)**
Laboratory corrosion tests - Accelerated chemical tests such as salt spray test, humidity and porosity tests; Field tests and Susceptibility test; ASTM standards for laboratory and on-site corrosion investigations. Non-Elecrochemical and Electrochemical methods: Weight loss method, Tafel and Linear polarizations and AC-Impedance techniques.

**Unit V: Corrosion Protection methods (9 hours)**
Corrosion prevention through selection of proper materials, design rules and its modifications, alloying additions; Coatings: Organic, Inorganic and Metallic coatings, Electro and Electroless plating and Anodising; Inhibitors: Principles and practice, Inhibitors for acidic neutral and other media; Cathodic and anodic protections and their specific uses/applications.

**Course Outcomes:**
At the end of the course, the student will be able to
1. Learn the basics of corrosion and its different forms.
2. Understand the corrosion behaviour of metals, alloys, ceramic materials, concrete and polymer materials.
3. Acquire knowledge on corrosion testing and monitoring.
4. Understand various corrosion prevention methods.

**List Of Experiments**
1. Determination of efficiency of the given inhibitor by gravimetric method.
2. Efficiency of cathodic protection by impressed current method.
3. Determination of anode efficiency in sacrificial anode system.
4. Standard test methods for specific gravity of pigments.
5. Determination of corrosion rate by galvanostatic polarization method [Tafel and linear Polarization methods].
6. Determination of corrosion rate by ac-impedance method.

7. Electroplating of Zinc over mild steel.

**Text Books**


1. Raj Narayan, An Introduction to Metallic Corrosion & its Prevention, Oxford & IBH Publishing Co., 1983.
2. Fontana. M.G., Corrosion Engineering, Tata McGraw Hill, 3rd Edition, 2005.
3. D.A. Jones, Principles and Prevention of Corrosion, 2nd Edition, Prentice Hall, 1996.
4. S.N.Banerjee, An introduction to Science of Corrosion and its inhibitors, Oxonian Press Ltd., New Dehhi, 1985.
5. N.V.Parthasarady, Practical Electroplating Handbook, Prentice Hall, New Jersey, 1989.


**Reference Books**


1. Revie, W.R. and Uhlig, H.H., Corrosion and Corrosion Control, 4th Edition, Wiley, 2008.
2. Zaki A. Principles of Corrosion Engineering and Corrosion Control, Elsevier Science & Technology Books, 2006.
3. Mondal K., Corrosion - Part I and II, NPTEL Course Material, Metallurgy & Material Science, Indian Institute of Technology, Kanpur, https://nptel.ac.in/courses/113104082/


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| PCC- MST 318 | Biomaterials | 3L:0T:0P | 3 Credits |
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**Course Objectives:**

1. The course has been designed to furnish young graduates with the necessary understanding of biomaterials and their implications for the betterment of mankind.
2. Evaluation of biomaterials and their compatibilities.
3. Understanding novel bio-materials and their future applications.

**Unit-I: Introduction to Material Science (9 hours)**

Basic concepts in material science; bulk properties of materials; surface properties of materials; Crystallography; mechanical properties; tribological properties; phase diagrams; electrical, optical, magnetic and thermal properties of materials.

**Unit-II: Introduction to Biomaterials (9 hours)**

Introduction and importance of biomaterials; Types of biomaterials: Metals, ceramics, polymers and composite biomaterials; Polymers: molecular weight determination - glassy and rubbery states, polymerization reactions, degradation mechanism; Metals: basic structure and alloys, Ceramics and Glasses: crystalline vs. non-crystalline Materials, Classification according to the physiological response of biomaterials: bioinert, bioactive and bioresorbable biomaterials.

**Unit-III: Host material interface (9 hours)**

Background in Biology: Soft and hard tissue, Cell migration, Cell culture, Cell storage and cell characterization, Cell signalling molecules, Growth factor delivery; Surface modification of biomaterials; Surface-protein interactions; Material-cell interactions; Tissue-material interactions; Blood-material Interactions; biocompatibility and rejection; Implants and infection - Inflammation; Wound healing and the foreign body response.

**Unit-IV: Assessment of biomaterials (9 hours)**

Sterilization of biomaterials; In vitro biochemical assays: cellular adhesion, cell viability using MTT, osteogenic differentiation using ALP assay; Biomineralization using Osteocalcin assay, Anticancer

activity; Histocompatibility assessment; Genotoxic assessment: Physical damage to DNA by biomaterial eluates; In vivo testing.

**Unit-V: Applications of biomaterials (9 hours)**

Applications of biomaterials in Tissue engineering, Drug delivery, Biosensing, Diagnostics, Sutures; Bioelectrodes - Biomaterials in Artificial Organs; Cardiovascular-artificial heart, heart valve; Dental implants: Adhesives and Sealants dialysis; biosensors and microarray; Nanocarriers in cancer therapy; Regulatory environment: FDA rules and regulations- legal and ethical issues related to biomaterials used in medical applications.

**Course Outcomes:**

1. The completion of course will develop the aptitude to design and understand new biomaterials for novel scientific avenues**.**

**Textbooks:**


1. W. D. Callister, "Materials Science and Engineering: An Introduction", John Wiley & Sons, 2007.
2. Buddy D.Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, Biomaterials Science: An Introduction to Materials in Medicine, Academic Press, 1st edition, 1997.
3. Biomaterials: An Introduction, J. Park and R.S. Lakes, Springer, 2007
4. Biomaterials: A Basic Introduction, Q. Chen and G. Thomas – CRC Press, 2016
5. Advanced Biomaterials: Fundamentals, Processing, and Applications, B. Basu, D.S. Katti and A. Kumar - John Wiley and Sons 2009


**References:**


1. Introduction to Dental Materials - 3rd Edition R. van Noort - Mosby, 2008
2. An Introduction to tissue-Biomaterial Interactions, K.C. Dee, D.A. Puleo and R. Bizios John Wiley and Sons, 2002
3. Introduction to Biomedical Engineering - 2nd Edition M.M. Domach - Pearson/Prentice Hall, 2009
4. An Introduction to Bioceramics, edited by L. L. Hench and J. Wilson, World Scientific.
5. Structural Biomaterials, by J. Vincent, Princeton University Press. 4. Recent articles will be cited as reference materials during some of the classes.


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| PCC-MST 320 | Materials Synthesis and Characterization Laboratory | 0L:0T:4P | 2 Credits |
|---|---|---|---|

**Course Objectives:**

This lab course gives practical exposure on synthesize different materials and characterize them using appropriate analytical techniques and teaches to interpret results with knowledge gained from the theory course on characterization of materials.

**List of Experiments (A minimum of 10 among the following experiments)**

- Synthesis of aluminosilicate by sol-gel route.
- Hydrothermal synthesis of ceramic powders.
- Precipitation reaction of mixed metal oxides.
- Graphene preparation by Hummer’s method.
- Synthesis of ZnO and its photocatalytic activity in the degradation of organic dyes.
- Fabrication of thin films by thermal evaporation.

- Thin film fabrication by electron beam evaporation.
- Film thickness measurement by ellipsometer.
- Nanocrystalline thin film by spin coating.
- Chemical bath deposition by dip coating.
- Fabrication of $TiO_2$ nanofibers by electro-spinning.
- Electrodeposition of polyaniline on ITO substrate.
- Electrophoretic deposition of tricalcium phosphate.
- Preparation of polymer nanocomposites and its mechanical properties.
- Thermal analysis of polymer materials using TGA and DSC.
- Particle size distribution and zeta potential analysis of metal oxide nanoparticles.
- Electroless deposition of Ag or Au on Si substrate
- Grain refinement studies using polarization microscope.
- Crystal structure and lattice parameters determination using XRD analysis.
- Crystallite size of materials using XRD analysis.
- Indexing of selected area diffraction patterns.
- FTIR analysis of ceramic materials.
- UV-Vis spectroscopy analysis of thin films.
- Chemical analysis by EDAX using SEM.
- TEM specimen preparation and observation.
- Preparation of Al-SiC composite by stir-casting method.
- Preparation of continuous fiber reinforced polymer composites.
- Preparation of non-continuous fiber reinforced polymer composites.
- Band gap determination by diffuse reflectance spectroscopy method.
- Polymer membrane electrolyte preparation and its porosity, electrolyte uptake and ionic conductivity studies.
- Diffusion and gas permeability measurement of polymer films.

**Course outcomes:**

On successful completion of this lab course, the students will have an ability to synthesis of materials and their characterization using advanced techniques.

**Reference Books**


1. Rabek, Jan F, Experimental methods in polymer chemistry -, John Wilely, New York, 1980.
2. D. Braun, H. Cherdron, M. Rehahn, H. Ritter, B. Voit, Polymer Synthesis: Theory and Practice Fundamentals, Methods, Experiments, Fourth Edition, Springer, 2004.
3. Barsoum, Michel, and M. W. Barsoum. Fundamentals of ceramics. CRC press, 2002.
6. Segal, David. Chemical synthesis of advanced ceramic materials. Vol.1. Cambridge University Press, 1991.
7. Pradeep, T. A textbook of nanoscience and nanotechnology. Tata McGraw-Hill, 2003.
8. C. N. R. Rao, h.c. mult. Achim Müller, A. K. Cheetham, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Wiley-VCH Verlag GmbH & Co. KGaA, 2004.


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| HSMC 304 | Project Management | 2L:1T:0P | 3 Credits |
|---|---|---|---|

**Course Objectives:**

1. To outline the need for Project Management
2. To highlight different techniques of activity planning
3. Project Planning & Management

**UNIT I: Introduction To Project Management and Project Selection (9 hours)**

Objectives of Project Management- Importance of Project Management- Types of Projects Project Management Life Cycle- Project Selection – Feasibility study: Types of feasibility Steps in feasibility study.

**UNIT II: Project Planning and Implementation (9 hours)**

Project Scope- Estimation of Project cost – Cost of Capital – Project Representation and Preliminary Manipulations - Basic Scheduling Concepts - Resource Levelling – Resource Allocation.

**UNIT III: Project Monitoring and Control (9 hours)**

Setting a base line- Project management Information System – Indices to monitor progress. Importance of Contracts in projects- Teamwork in Project Management - Attributes of a good project team – Formation of effective teams – stages of team formation.

**UNIT IV: Project Closure (9 hours)**

Project evaluation- Project Auditing – Phases of project Audit- Project closure reports Guidelines for closeout reports.

**UNIT V: Special Topics in Project Management (9 hours)**

Computers, e-markets and their role in Project management- Risk management – Environmental Impact Assessment. Case studies in Project management.

**Course Outcomes:**

1. Evaluate and select the most desirable projects.

**Text Book**


1. Berkun, Scott (2008), Making Things Happen: Mastering Project Management, O'Reilly Media: Cambridge, MA.
2. Campbell, Clark A. (2006), The One-Page Project Manager: Communicate and Manage
3. Any Project With a Single Sheet of Paper, Wiley: New York.
4. Cook, Curtis R. (2004), Just Enough Project Management, McGraw-Hill: Boston, MA.


**Reference Books:**


1. Crowe, Andy (2006), Alpha Project Managers: What the Top 2% Know that Everyone Else Does Not, Velociteach: Kennesaw, GA.
2. Khanna, R. B. (2011), Project Management, PHI Learning Private Limited, New Delhi.
3. Kendrick, Tom (2004), The Project Management Toolkit: 100 Tips and Techniques for Getting the Job Done Right, AMACOM Books: Boston, MA.
4. Pacelli, Lonnie (2004), The Project Management Advisor: 18 Major Project Screw-Ups, and how to Cut them off at the Pass, Prentice Hall: New York.
5. Rose, Kenneth H. (2005), Project Quality Management: Why, What and How, J. Ross Publishing: Ft. Lauderdale, FL.
6. Snead, G. Lynne (2002), The Project Management Scorecard: Measuring the Success of Project Management Solutions, Butterworth-Heinemann: Oxford.


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**SEMESTER 7**

| S.No. | Category | Code | Course Title | L | T | P | Total Hr | Credits |
|---|---|---|---|---|---|---|---|---|
| 1. | PEC | PEC -MST 4xx | Professional Elective-II | 3 | 0 | 2 | 5 | 4 |
| 2. | PEC | PEC -MST 4xx | Professional Elective-III | 3 | 0 | 2 | 5 | 4 |
| 3. | OEC | OEC - xxx 4xx | Open Elective -I | 3 | 0 | 0 | 3 | 3 |
| 4. | OEC | OEC- xxx 4xx | Open Elective-II | 3 | 0 | 3 | 3 | 3 |
| 5. | PROJ | PROJ-MST 402 | Minor Project | 0 | 0 | 10 | 10 | 5 |
| 6. | SEM | PROJ-MST 403 | Seminar | 1 | 0 | 0 | 1 | 1 |
| **Total** | | | | | | | **27** | **20** |

**SEMESTER 8**

| S.No | Category | Code | Course Title | L | T | P | Total Hr | Credits |
|---|---|---|---|---|---|---|---|---|
| 1. | OEC | OEC - xxx 4xx | Open Elective-III (SWAYAM/NPTEL/MOOC) | 2 | 1 | 0 | 3 | 3 |
| 2. | PROJ | PROJ-MST 404 | Major Project | 0 | 0 | 16 | 16 | 8 |
| **Total** | | | | | | | **19** | **11** |

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# PROFESSIONAL ELECTIVES [PEC]

**(Total 3/4 Courses to be taken with the total credits of 12)**

| Sl. | Code No. | Subject | Semester | Credits |
|---|---|---|---|---|
| *TECHNOLOGY/ INDUSTRY SECTOR BASED* | | | | |
| 1 | PEC -MST 201 | Computational Methods in Engineering | 3/**4** | 4 |
| 2 | PEC - MST 202 | Additive Manufacturing | 3/**4** | 4 |
| 3 | PEC - MST 203 | Iron and Steel Making | 3/**4** | 4 |
| 4 | PEC – MST 410 | Thin Film Technology | 7/8 | 4 |
| 5 | PEC - MST 411 | Sensor Materials and Technologies | 7/8 | 4 |
| 6 | PEC - MST 412 | Extractive and Powder Metallurgies | 7/8 | 4 |
| 7 | PEC – MST 413 | Rubber Technology | 7/8 | 3 |
| 8 | PEC - MST 414 | Modern Manufacturing Process | 7/8 | 3 |
| 9 | PEC - MST 415 | Micro- and Nano-Fluidics | 7/8 | 3 |
| 10 | PEC - MST 416 | Semiconductor Materials and Devices | 7/8 | 3 |
| 11 | PEC - MST 417 | Industrial Electrochemical Technology | 7/8 | 4 |
| 12 | PEC- MST 418 | Materials for Clean Energy Conversion & Storage Devices | 7/8 | 4 |
| 13 | PEC - MST 419 | Non-destructive Techniques | 7/8 | 4 |
| 14 | PEC–MST 420 | Advanced Nanobiotechnology | 7/8 | 4 |
| 15 | PEC -MST 421 | Industrial Nanotechnology | 7/8 | 3 |
| | | **Total Credits (To be Taken)** | | **12** |

| PEC -MST 201 | Computational Methods in Engineering | 3L:0T:2P | 4 Credits |
|---|---|---|---|

**Course Objectives**

The course would enable the students

1. To familiarize different numerical methods to solve problems engineering and material's simulation methods.
2. To understand the mathematical concepts involved in simulations of different systems.
3. To write computer programs using free software such as SciLab.
4. To identify an appropriate method to solve practical problems numerically.

**UNIT-I: Interpolation Methods for curve fitting (8 hours)**

Lagrange Interpolation – Neville's algorithm - Linear interpolation – Polynomial interpolation – Cubic spline – Rational function interpolation

**UNIT -II: Numerical Differentiation and Integration (10 hours)**

**Numerical Differentiation** – Three and Four-point formulae from Taylor series – first and second order derivatives - Ordinary differential equations: Euler and Runge Kutta methods. **Numerical integration**: Newton- Cotes integration formulae – Rectangular, Trapezoidal rule, and Simpson's 1/3 rules – Simple and Composite rules - Gauss quadrature method – Problems using 2- and 3-point Gauss quadrature formulas.

**UNIT-III: Nonlinear and Linear equations (9 hours)**

Nonlinear: Bisection method – Newton's method – Method of Secants. Linear: Gauss Elimination method – Gauss-Jordan Elimination method - Iterative methods for linear systems – Jacobi method – Gauss-Seidel method – Convergence - Eigenvalue problems - Computing Eigenvalues and Eigenvectors.

**UNIT-IV: Random numbers and Monte Carlo methods (9 hours)**

Definition and Types– Random number Generators (RNG) for True and Pseudo Random Numbers – - Properties of RNG - Uniformly distributed Pseudo random numbers - Computer clock – Linear Congruence method – Middle square method – Test for Random Numbers – Distribution, Correlation and Run Tests – Random numbers with Exponential and Normal distribution – Box-Muller algorithm - Simulation of radioactive decay - Numerical Integration using Monte Carlo simulation techniques for 1D case.

**UNIT-V: Programming in SciLAB (9 hours)**

Basic definitions - Roots of equations – Bisection method- Fixed point iteration - Newton-Raphson method – Method of Secants - Systems of nonlinear equations. Numerical linear algebra – Gauss elimination, matric inversion, power method for finding eigen values, Runge-Kutta method.

**Course Outcomes**

1. Learn interpolation methods for curve fitting.
2. Use numerical methods to do differentiation and integration.
3. Solving the nonlinear and linear equations using appropriate numerical methods.
4. Use random numbers in simulations after understanding them completely.
5. Get the skill in writing computer programs of numerical methods in the SciLab software.

**Practice Methods**

(1) Learn the basics of SciLAB programs
(2) Write programs in SciLAB to understand the Matrix operations.
(3) Write SciLAB program to find the root of the given equation by Newton-Raphson method.
(4) Compute the solutions for the given set of linear equations by Gauss elimination using SciLAB program.
(5) Write the algorithm and program in SciLAB for solving differential equation via Runge-Kutta method.
(6) Find the integration values of the tabular values by Simpson's 1/3 rule by writing a SciLAB program.
(7) Understand the image import and processing the image in SciLAB.
(8) Import the data set and plot it in a graphical format.
(9) Write a program in SciLAB for least squares fitting.

**Text Book:**

1. Introductory Computational Physics, Andi Klein and Alexander Godunov, Cambridge University Press, Cambridge, UK, ISBN: 978-0-521-82862-8 (Hardback), 2006
2. Ferziger, J. H., Numerical Methods for Engineering Applications, 2nd ed., Wiley- Interscience ISBN 978-0471116219. (1998).

**Reference Book:**

1. Computational methods in Physics and Engineering, 2nd Edition, Samuel S.M. Wong, World Scientific-Singapore (2003) ISBN: 9810230176,
2. Advanced Engineering Mathematics, Erwin Kreyszig, Tenth Edition, Wiley (2018). ISBN: 978-1-119-44684-2

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| PEC-MST-202 | ADDITIVE MANUFACTURING | 3L:0T:2P | 4 Credits |
|---|---|---|---|

**Course Objectives:**

1. To know the principle, methods, possibilities and limitations as well as environmental effects of Additive Manufacturing technologies.
2. To be familiar with the characteristics of the different materials those are used in Additive Manufacturing technologies.

**UNIT-I: Introduction (9 hours)**

Overview of additive manufacturing technologies – Historical development and evolution of 3D printing - Benefits and limitations of additive manufacturing – Classification: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing – Applications.

**UNIT-II: Design for Additive Manufacturing (9 hours)**

Design tools: Data processing - CAD model preparation – Part orientation and support structure generation – Model slicing –Tool path generation- Design for Additive Manufacturing: Concepts and objectives- AM unique capabilities – DFAM for part quality improvement- Customised design and fabrication for medical applications.

**UNIT-III: Photopolymerization and Powder Bed Fusion Processes (9 hours)**

Photopolymerization: SLA-Photo curable materials – Process - Advantages and Applications. Powder Bed Fusion: SLS-Process description – powder fusion mechanism – Process Parameters– Typical Materials and Application. Electron Beam Melting.

**UNIT-IV: Extrusion Based and Sheet Lamination Processes (9 hours)**

Extrusion Based System: FDM-Introduction – Basic Principle – Materials – Applications and Limitations – Bioextrusion. Sheet Lamination Process:LOM- Gluing or Adhesive bonding – Thermal bonding.

**UNIT-V: Printing Processes and Beam Deposition Processes (9 hours)**

Droplet formation technologies – Continuous mode – Drop on Demand mode – Three-Dimensional Printing – Advantages – Bioplotter - Beam Deposition Process: LENS- Process description – Material delivery – Process parameters – Materials – Benefits – Applications.

**Course Outcome:**

On completion of this course, students will learn about a working principle and construction of Additive Manufacturing technologies, their potential to support design and manufacturing, modern development in additive manufacturing process and case studies relevant to mass customized manufacturing.

**List of Experiments (Any 5 experiments)**

1. CAD Design for 3D Printing.
2. Prepare 3D models for printing using slicing software.
3. Calibrating 3D printers for optimal print quality.
4. Prepare 3D models using different printing materials such as PLA (or) ABS.
5. Prepare 3D models using different printing materials such as PETG (or) TPU.
6. Compare the mechanical properties of different 3D printing materials.
7. Learn about post-processing methods for improving aesthetics and functionality.

**Text Books:**

1 Chua C.K., Leong K.F., and Lim C.S., **"**Rapid prototyping: Principles and applications**"**, Third edition, World Scientific Publishers, 2010.

2 Ian Gibson, David W.Rosen, Brent Stucker **"**Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing**"** Springer, 2010.

**Reference Books:**

1 Andreas Gebhardt **"**Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing**"** Hanser Gardner Publication 2011.

2 Kamrani A.K. and Nasr E.A., **"**Rapid Prototyping: Theory and practice**"**, Springer, 2006.

3 Liou L.W. and Liou F.W., **"**Rapid Prototyping and Engineering applications: A tool box for prototype development**"**, CRC Press, 2007.

4 Tom Page **"**Design for Additive Manufacturing**"** LAP Lambert Academic Publishing, 2012.

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| PEC -MST 203 | Iron and Steel Making | 3L:0T:2P | 4 Credits |
|---|---|---|---|

**Course Objectives:**

1. To become familiar with iron making and steel making
2. To describe the physical and chemical processes that take place during iron making and steelmaking
3. To get a feel for what is happening in the steel industry

**UNIT-I: Raw Materials and Burden Preparation (9 hours)**

Iron ore classification, Indian iron ores, limestone and coking coal deposits, problems associated with Indian raw materials, Iron ore beneficiation and agglomeration, Briquetting, sintering, Nodulising and pelletizing, testing of burden materials, burden distribution on blast furnace performance.

**UNIT-II: Principles and Processes of Iron Making (9 hours)**

Blast furnace parts, construction and design aspects, ancillary equipment for charging, preheating the blast, hot blast stoves, gas cleaning, Blast furnace operation, irregularities and remedies, Blast furnace instrumentation and control of furnace Compositional control of metal and slag in blast furnace, modern trends in blast furnace practice.

Reduction of iron ores and oxides of iron by solid and gaseous reductions-thermodynamics and kinetics study of direct and indirect reduction, Gruner's theorem, blast furnace reactions. C-O and Fe-C-O equilibria, Rist diagrams, Ellingham diagram, material and heat balance- Sponge Iron making.

**UNIT-III: Principles of Steel Making (9 hours)**

Review of traditional steel making; Development of steel making processes, physico-chemical principles and kinetic aspects of steel making, carbon boil, oxygen-transport mechanism, desulphurisation, dephosphorisation, Slag Theories, slag-functions, composition, properties and theories - slag metal interaction, role of slags in refining, continuous casting; foaming slag; removal of S and P; deoxidizers, alloying; raw materials for steelmaking and plant layout.

**UNIT-IV: Steel Making Processes (9 hours)**

Open Hearth process- constructional features, process types, operation, modified processes, Duplexing, pre-treatment of hot metal. Bessemer processes, Side Blown Converter, Top Blown processes-L. D, L.D.A.C., Bottom blown processes, combined blown processes, Rotating oxygen processes - Kaldo and Rotor, Modern trends in oxygen steel making processes-Electric Arc and Induction furnace-constructional features. Steel Classifications and Standards-National and International- Alloy Designation.

**UNIT-V: Ladle Metallurgy (9 hours)**

Production practice for plain carbon steels, stainless steels, tool steels and special steels, Secondary steel making processes, continuous steel casting process – Deoxidation and teeming practice. Principle, methods and their comparison, Killed, Rimmed and Capped steels, Degassing practices, ingot production, ingot defects and remedies. Recent trends in steel making technology.

**Course Outcomes:**

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

1. To understand the iron and steel making process with practical exposure
2. Describe the methods for control of quality in iron and steel production

**List of Lab Experiments: (Any one Field Trip OR 5 Experiments)**

1. Industrial visit to Steel Plants in India to learn Iron and Steel Making Technology
2. Field trip to Iron Ore Mines in India to Iron Ore Mineral Extraction and Processing
3. Physical Testing of Iron Ore
4. Laboratory Studies on Iron Ore Sintering and Testing : Process Simulation only
5. Preparation of Medium Carbon iron-Carbon alloy by Vacuum Arc Melting Furnace
6. Preparation of High Carbon iron by Vacuum Arc Melting Furnace
7. Preparation of Fe-Ni alloy by Vacuum Arc Melting Furnace
8. Preparation of Fe-Cr alloy by Vacuum Arc Melting Furnace
9. Preparation of Fe-Cr-Ni alloy by Vacuum Arc Melting Furnace
10. To study the microstructure of low carbon steel, mild steel and high carbon steel.

**Text Books:**

1. Dipak Mazumdar, "A First Course in Iron and Steel Making", Universities press – IIM, Series in Metallurgy and Materials Science, India, 2015.
2. Tupkary, R. H.& Tupkary V.R., "An Introduction to Modern Iron Making", Khanna Publishers, 4th edition, 2016
3. Tupkary, R. H.& Tupkary V.R., "An Introduction to Modern Steel Making", Khanna Publishers, New Delhi, 2004.
4. Gupta O. P., 'Elements of Fuels, Furnace and Refractories', 2nd Edition, Khanna Publishers, 1990

**Reference Books:**

1. Ahindra Ghosh and Amit chatterjee, "Iron Making and Steel Making – Theory and Practice", Prentice Hall of India Private Ltd., New Delhi 2008.
2. Biswas, A. K., "Principles of blast furnace iron making: theory and practice", SBA Publications, Kolkata, 1994.
3. Bashforth, G. R., "Manufacture of Iron and Steel", Vol. I, Chapman and Hall London, 1964.
4. Bashforth, G. R., "Manufacture of Iron and Steel", Vol.2, 3rd Edition, Chapman & Hall,London, 1964.
5. "Making, Shaping and Treating of Steel", US Steel Corporation, 11th edition, 1994.

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| PEC-MST 410 | Thin Film Technology | 3L:0T:2P | 4 Credits |
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**Course Objectives:**

1. To enable the students to understand about the difference between bulk and thin film.
2. To explain the theory of formation of thin film and the fabrication
3. To provide a comprehensive knowledge on physics and chemistry of thin film development.
4. To expose the students to various physical and chemical vapor deposition of thin films.
5. To understand the importance thinfilm technology for electronics, magnetic, optical, mechanical surface engineering and biomedical applications

**UNIT –I: Physics of Thin Film Growth (9 hours)**

Nucleation and growth – adsorption, surface diffusion, chemisorption, nucleation, microstructure formation, adhesion; Growth modes and Zone models - capillarity model, atomistic model; Four stages of thin film growth, cluster coalescence and depletion, zone model for sputtering and evaporation, Island growth, Volmer weber, Layer growth, Van Vawler Megrue, S.K. mode.

**UNIT –II: Vacuum Technology (9 hours)**

Principles of vacuum pumps - rotary pumps - low vacuum, diffusion pump - high vacuum; Turbomolecular pump, Ion pump Cryopumps - ultra-high vacuum; vacuum gauges (McLeod/ Bourdon/Pirani/Penning); Materials, components, fabrication, testing of vacuum chambers.

**UNIT – III: Physical Vapor Deposition (PVD) techniques (9 hours)**

Physical Vapor Deposition – physical mechanism basics - Hertz Knudsen equation; mass evaporation rate; Knudsen cell, Directional distribution of evaporating species, Raoult's law; Plasmas, the Townsend discharge, Ion-surface interactions, Sputtering Yield, Sigmund Theory, Electron beam evaporation, Cathodic arc deposition; Classification of Sputtering deposition –of Sputtering: RF sputtering, reactive sputtering, magnetron sputtering; Pulsed Laser Deposition.

**UNIT–IV: Chemical Vapor Deposition (CVD) techniques (9 hours)**

Plasma Enhanced CVD (PECVD), Metal Organic Chemical Vapor Deposition (MOCVD); Atomic Layer Deposition (ALD); Thermally activated CVD - Laser Chemical Vapor Deposition (LCVD) – Gaussian beam concepts of lasers, principles of Nd:YAG, Ar-ion and Excimer lasers - laser materials interaction, LCVD of carbon nanostructures, Laser annealing of semiconductors.

**UNIT – V: Thin Film Characterization and applications (9 hours)**

Electrical measurement - Sheet resistance, Capacitance and Volt–Farad characterization, Dynamical Hot-Probe characterization; Film thickness and morphology - Coherence Scanning Interferometry; Magnetic measurement – Vibrating Sample Magnetometer and magneto-optical Kerr effect (MOKE) magnetometer; applications - Semiconductor thin films optoelectronics, infrared coatings, multilayer films for magnetic memory and nanostructured biomedical films.

**Course outcomes:**

1. At the end of the course students will be able to
2. To understand the principle of thin film deposition.
3. To understand the nucleation and growth of thin films.
4. To gain knowledge on vacuum pumps, deposition techniques and instrumentation.

**List of Lab Experiments: (Any 5 Experiments)**

1. Preparation of the Metal films by Thermal Evaporation/E-beam Evaporation
2. Preparation of the Transparent Conductive Oxide coating by DC magnetron sputtering
3. Preparation of Metal Oxide Film by Pulsed Laser Deposition
4. Preparation of the Carbon nanotubes by the CVD process.
5. Preparation of the metal oxide thin films Sol-gel or Dip coating technique.
6. Determination of crystalline size and macrostrain by using XRD technique.
7. Determination of electrical resistance properties of thinfilm.
8. Study of thickness, roughness and Morphology of Thinfilm by Optical Profilometer

**Text Books:**


1. The Materials Science and Thin Films by Milton Ohring, Academic Press 1992.
2. Thin Film Deposition: Principles and Practice by Donald L. Smith, McGraw Hill 1995.
3. Vacuum Technology, Thin Films, and Sputtering by R. V. Stuart Academic Press 2012
4. Thin Film Device Applications by K.L.Chopra and Inderjeet Kaur, Plenum Press 1983
5. Physical Vapor Deposition of Thin Films by J.E. Mahan, Wiley 2000
6. Vacuum Deposition of Thin Films by L. Holland, Chapman and Hall Publisher, 1966

7. Thin Film Growth: Physics, Materials Science and Applications by Zexian Cao, Woodhead Publishing Series in Electronic and Optical Materials, 2011
8. Nanostructured Thin Films and Coatings by Sam Zhang, CRC Press, 2010

**Reference Books:**

1. Handbook of Thin Film Technology by Meisel and Glang, Academic Press 1970.
2. Handbook of Thin Film Deposition by Seshan Krishna, CSU e-book, 2012
3. Thin Film Materials: Stress, Defect Formation and Surface Evolution by L.B. Freund and S.Suresh, .Cambridge University Press; 1st edition, 2008
4. Solid surfaces, Interfaces and Thin Films by Hans Luth, Springer Publishers, 2010.
5. Physics of Surfaces and Interfaces, by HaraldIbach, Springer Publishers, 2006.
6. Film Solar Cells: Fabrication, Characterization and Applications by Jef Poortmans Vladimir Arkhipov, Wiley 2006
7. Optical Interference coatings by N. Kaiser & Hans Pulker, Springer Series in Optical Sciences, 2003
8. Handbook of Infrared Optical Materials Edited By Paul Klocek, CRC Press, 2019
9. Thin Film Coatings for Biomaterials and Biomedical Applications, Hans J Griesser, Woodhead Publishing Series in Biomaterials, 2016

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|---|---|---|---|
| **PEC -MST 411** | **Sensor Materials & Technologies** | **3L:0T:2P** | **4 Credits** |

**Course Objectives:**

Chemical Gas Sensors (CGS) are gaining attention day by day due to the advent of smart systems. Sensors are an integral part of almost all the modern electronic appliances. To provide in depth knowledge in physical principles applied in sensing, measurement and a comprehensive understanding on how measurement systems are designed, calibrated, characterised, and analysed. Further to apply them for checking materials in accordance with industry specifications and standards sensors.

**UNIT – 1: Introduction (9 hours)**

Difference between sensor, transmitter and transducer - Primary measuring elements - selection and characteristics: Range; resolution, Sensitivity, error, repeatability, linearity and accuracy, impedance, backlash, Response time, Dead band. Signal transmission - Types of signals: Pneumatic signal; Hydraulic signal; Electronic Signal. Principle of operation, construction details, characteristics and applications of potentiometer, Proving Rings, Strain Gauges, Resistance thermometer, Thermistor, Hot-wire anemometer, Resistance Hygrometer, Photo-resistive sensor.

**UNIT– 2: Types of Nano-Sensors (9 hours)**

Nanosensors: Temperature Sensors, Smoke Sensors, Sensors for aerospace and defence: Accelerometer, Pressure Sensor, Night Vision System, Nano tweezers, nano-cutting tools, Integration of sensor with actuators and electronic circuitry Biosensors.

**UNIT– 3: Actuators (9 hours)**

Definition, types and selection of Actuators; linear; rotary; Logical and Continuous Actuators, Pneumatic actuator- Electro-Pneumatic actuator; cylinder, rotary actuators, Mechanical actuating system: Hydraulic actuator - Control valves; Construction, Characteristics and Types, Selection criteria. Electrical actuating systems: Solid-state switches, Solenoids, Electric Motors- Principle of

operation and its application: D.C motors - AC motors - Single phase & 3 Phase Induction Motor; Synchronous Motor; Stepper motors - Piezoelectric Actuator.

**UNIT– 4: Micro Sensors and Micro Actuators (9 hours)**

Micro Sensors: Principles and examples, Force and pressure micro sensors, position and speed micro sensors, acceleration micro sensors, chemical sensors, biosensors, temperature micro sensors and flow micro sensors.

Micro Actuators: Actuation principle, shape memory effects-one way, two way and pseudo elasticity. Types of micro actuators- Electrostatic, Magnetic, Fluidic, Inverse piezo effect, other principles.

**UNIT– 5: Sensor Materials and Processing Techniques**

Materials for sensors: Silicon, Plastics, metals, ceramics, glasses, nano materials Processing techniques: Vacuum deposition, sputtering, chemical vapour deposition, electro plating, photolithography, silicon micro machining, Bulk silicon micro machining, Surface silicon micro machining, LIGA process.

**Course Outcome:**

Use concepts in common methods for converting a physical parameter into an electrical quantity. To choose an appropriate sensor comparing different standards and guidelines to make sensitive. measurements of physical parameters like pressure, flow, acceleration, etc. To design and develop sensors using optical methods with desired properties. Evaluate performance characteristics of different types of sensors. Locate different type of sensors used in real life applications and paraphrase their importance. To create analytical design and development solutions for sensors.

**Text Books:**


1. Sensors: Micro & Nanosensors, Sensor Market trends (Part 1&2) by H. Meixner.
2. Patranabis.D, “Sensors and Transducers”, Wheeler publisher, 1994.
3. Sergej Fatikow and Ulrich Rembold, “Microsystem Technology and Microbotics”, First edition, Springer –Verlag NEwyork, Inc, 1997.
4. Jacob Fraden, “Hand Book of Modern Sensors: Physics, Designs and Application” Fourth edition, Springer, 2010.


**Reference Books:**


1. Robert H Bishop, “The Mechatronics Hand Book”, CRC Press, 2002.
2. Thomas. G. Bekwith and Lewis Buck.N, Mechanical Measurements, Oxford and IBH publishing Co. Pvt. Ltd.,
3. Massood Tabib and Azar, “Microactuators Electrical, Magnetic,thermal, optical, mechanical, chemical and smart structures”, First edition, Kluwer academic publishers, Springer, 1997.
4. Manfred Kohl, “Shape Memory Actuators”, first edition, Springer


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|---|---|---|---|
| **PEC - MST 412** | **Extractive and Powder Metallurgies** | **3L:0T:2P** | **4 Credits** |

**Course Objective:**

1. To enable the student to know the process of raw materials extraction to refined process
2. To know process flow chart to process ferrous and non-ferrous materials
3. To understand the engineering of powder to components

**UNIT-I: Principles of Metal Extraction (9 hours)**

Scope of extractive metallurgy, occurrence of metals in nature, minerals and ores. Elementary concepts of Mineral processing and extraction of metals

**UNIT-II Methods of Metal Extraction (9 hours)**

Pyrometallurgy: Drying and calcinations, roasting & derivation of roasting conditions by Kelloss's diagram, relevance of Ellingham diagram in metal extraction, reduction of metal oxides, matte smelting and converting, metal refining processes: fire-refining, liquation and distillation. Pyrometallurgical process: Calcination, roasting, smelting, refining of leach solution, solvent extraction and ion exchange processes. Hydrometallurgical processes: Principles and types of leaching, refining of leach solution, cementation, solvent extraction and ion exchange processes, metal recovery from aqueous phase Electrowinning and electrorefining, aqueous and fused salts, electrolysis. Simplified flow sheets for the production of iron and steel, Al, Cu, Zn and Pb.

**UNIT-III: Refining of Metal (9 hours)**

General methods of refining - Basic approaches, preparation of pure compounds, purification of crude metal produced in bulk

**UNIT- IV: Powder Processing (9 hours)**

Manufacturing of Powders: Basics methods, Mechanical fabrication techniques; Electrolytic fabrication techniques, Chemical fabrication techniques, Atomization techniques. Production of powders. Powder Characterization: Experimental methods for measuring particle size, shape, distribution, surface area; Significance of true, apparent and tap densities of powders; Flow rate; compressibility and green strength; Characteristics of powders

**UNIT-V: Powder Compaction and Application (9 hours)**

Mixing and Blending: Dry Mixing, wet mixing; Powder Lubrication Compaction: Fundamentals of Compaction - Powder compaction methods - Injection Moulding - Influence of Material and Powder Characteristics on compaction Sintering Behaviour: Sintering fundamentals - Sintering Theory - Liquid and Solid state Sintering - Mixed Powder Sintering - Sintering Atmosphere, Sintering Furnaces; Full Density Processing. Finishing Operations: Machining; Heat Treatments; Surface Treatments; Applications: Competitive Processes - powder metallurgy products: bearings, filters, friction parts, electrical contact materials, porous parts, near net shape manufacturing techniques, modern applications of P/M parts.

**Course Outcomes:**

After completion of the course the student should be able to

(i) Illustrate flowsheet of process route for any types of ore,
(ii) Apply thermodynamics principles when dealing with any type of ore,
(iii) Analyze the proper requirement of different raw materials for metal production and preparation of components by powder metallurgy route

**List of Lab Experiments:**

1. To study the kinetics of roasting of material by weight loss method.
2. Determination of gas solid equilibrium during decomposition of carbonates
3. To Study the particle size distribution due to crushing and grinding of the give sample.
4. Sintering of ceramic powder and study their density and morphology
5. To Study various Characteristics of metal powders and evaluate green density as well as strength Characteristics (hardness) of Cold-compacted and sintered (Conventional) compacts.
6. Preparation of alloys by powder metallurgy route

**Text books:**

1. B.A. Wills, Mineral Processing Technology, 8th Ed., Butterworth Heinemann, Elsevier, 2015.
2. H.S. Ray, A. Ghosh, Principles of Extractive Metallurgy, New Age International Publishers, 2018
3. T. Rosenquist, Principles of Extractive Metallurgy, McGraw Hill, 1983
4. J.D. Gilchrist, Extraction metallurgy, Pergamon Press, 1989
5. Randall M. German, Powder Metallurgy & Particulate Materials Processing, Metal Powder Industry, 2005.
6. Anish Upadhyaya and G.S. Upadhyaya: Powder Metallurgy: Science, Technology and Materials, Universities Press-IIM Series in Metallurgy and Materials Science, 2011.

**References books:**

1. S.K. Jain, Mineral Processing Technology, 2nd Ed., CBS Publishers, 2001
2. W.L. McCabe, J.C. Smith, P. Harriott, Unit operation in Chemical Engineering, McGraw Hill, 7th Ed., 2017
3. H.S. Ray, R. Sridhar and K.P. Abraham, Extraction of non-ferrous Metals, East West Press, 2020
4. R.A Higgins, Engineering metallurgy (vol. I & II) ELBS, 1993.
5. Fritz V. Lenel, Powder metallurgy: principles and applications, , Metal Powder Industries Federation, 1980
6. G. S. Upadhyaya, Powder Metallurgy Technology, Cambridge International Science Publishing, 2002

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| PEC-MST 413 | Rubber Technology | 3L:0T:0P | 3 Credits |
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**Course Objectives**

1. To understand the concept of flexible polymer chains and difference between rubbers, plastics and fibres in terms of Tg.
2. To appreciate the influence of chemical structure on various properties of rubbers.
3. To acquire basic knowledge of Natural rubber–production, properties & uses.
4. To become familiar with manufacture, properties and uses of synthetic and high-Performance rubbers.
5. To become familiar with the concept, manufacture and properties of TPE's.

**UNIT-I (12 hours)**

Fundamentals of Rubber: Criteria for a polymer to behave as a rubber – structure vs Tg, chemical, mechanical and electrical properties – polymerization types and techniques involved in production of general purpose rubbers – ozone attack on rubbers– protection against oxidation - vulcanisation – effect of crosslink density on properties – role of accelerators, activators – non–sulphur vulcanisation systems. Degradation and aging of rubber, modification of rubber, theory of rubber elasticity, Rubber reinforcement, types of fillers, carbon black.

**UNIT-II (12 hours)**

Synthetic Rubbers: General purpose rubbers: Manufacture, structure, vulcanization, properties and applications of SBR, polybutadiene and polyisoprene rubber. Special purpose rubbers: Manufacture, structure, properties and applications of Neoprene rubber, EPDM, butyl rubber, nitrile rubber.

**UNIT-III (12 hours)**

Specialty rubbers – Manufacture, properties, vulcanization and applications of EVA, polyurethanes, hypalon rubber, silicone rubber and Fluorocarbon rubber. Thermoplastic elastomers: classification, preparation, properties and applications of thermoplastic elastomers based on blends, polyurethane and polyesters. Ionomers: different types, preparation and properties.

**UNIT-IV (12 hours)**

Processing of Rubber: Rubber processing – mixing operations – composition, concentration, stabilisation, coagulation – forming operations – calendering – extrusion –spreading and moulding operations. Manufacture of Tyres and Tubes: Rubber product manufacture – tyres – functions, requirements – basic design reinforcing systems –construction – manufacture – testing – tube manufacture– compounding for tyre and tube.

**UNIT-V (12 hours)**

Rubber Products: Belting and hoses – conveyor, transmission (V and flat) belting. troughing moulded, braided and hand built hoses – compounding - footwear and ports goods – hot air vulcanized – compression moulded – direct moulded process for shoe bottoming – injection moulded sole and heel units – safety and antistatic foot wear – micro and macro cellular rubbers – expanding rubber by nitrogen gassing and chemical blowing agents– tennikoit rings.

**Course Outcomes:**

On successful completion of the course, the students will be able to:

1. Explain the importance and functions of different rubber compounding additives and their normal dosages.
2. Design formulations based on different rubbers and additives.

3. Understand the chemistry of vulcanization process.
4. Describe vulcanization process, techniques to assess the state of cure.
5. Explain the classification of elastomers, preparation, properties, processing and applications of various general purpose elastomers.
6. Understand the structure, properties and applications of specialty rubbers.
7. Understand the properties and applications of thermoplastic elastomers and ionomers.

**Text Books:**


1. M.Morton, Rubber Technology, Van Nostrand Reinhold, 1987.
2. Whelan and K.S.Lee, Developments in Rubber Technology, Vol. 1 – 4, Applied Science Publishers, London 1981.
3. Erman, B. Mark, J.E. Science and Technology of Rubber, Academic Press, Florida, 2005.
4. J. A. Brydson, Rubbery Material and their Compound', Kluwer Academic Publishers Group, 2001.
5. C. M. Blow and C.Hepburn, "Rubber Technology and Manufacture", 2rd Edn.,Butterworths, London, 1982.
6. Kothandaraman, B. Rubber Materials, Ane Books Pvt Ltd, New Delhi, 2008.


**Reference Books:**


1. A.K. Bhowmick and H.L.Stephens, Hand Book of Elastomers, Marcel Dekker, New York, 1988.
2. Technology of Rubber & Rubber Goods Industries, Engineers India Research Institute, New Delhi, 2009.
3. Whelan, Injection Moulding Machine, Elsevier Publications, London, 1989.


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| PEC-MST 414 | Modern Manufacturing Process | 3L:0T:0P | 3 Credits |
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**Course Objectives:**

To understand various machining processes and complex parts with high accuracy by using non-traditional machining processes.

**UNIT-I: Introduction (12 hours)**

Need of non-traditional machining processes – Classification based on energy, mechanism, source of energy, transfer media and process; Process selection based on physical parameters, shapes to be machined, process capability and economics – Overview of all processes.

**Unit-II: Mechanical Process (12 hours)**

**Ultrasonic Machining:** Principle- Transducer types – Concentrators - Abrasive Slurry – Process Parameters – Tool Feed Mechanism – Advantages and Limitations – Applications. **Abrasive Jet Machining:** Process- Principle – Process Variables – Material Removal Rate - Advantages and Limitations – Applications. **Water Jet Machining:** Principle – Process Variables - Advantages and Limitations – Practical Applications.

**Unit-III: Electrical Discharge Machining (12 hours)**

Mechanism of metal removal – Dielectric Fluid – Flushing methods - Electrode Materials - Spark Erosion Generators – Electrode Feed System – Material Removal Rate – Process Parameters – Tool Electrode Design – Tool wear Characteristics of Spark Eroded Surfaces- Advantages and

Limitations – Practical Applications. **Electrical Discharge Wire Cut and Grinding:** Principle – Wire Feed System - Advantages and Limitations – Practical Applications

**Unit-IV: Chemical Machining (12 hours)**

Fundamentals, principle, classification and selection of etchant - chemical milling, engraving, blanking - advantages and limitations – Applications; **Electro Chemical Machining:** Electro-chemistry of the process-Electrolytes - Electrolyte and their Properties – Material Removal Rate – Tool Material – Tool Feed System – Design for Electrolyte Flow – Process Variables - Advantages and Limitations – Applications; **Electro Chemical Grinding:** Honing, cutting off, Deburring and turning.

**Unit-V: High Energy Machining Process (12 hours)**

Electron Beam Machining, Laser Beam Machining, Ion Beam Machining, Plasma Arc Machining – Principle, advantages, limitations and applications.

**Course Outcomes:**

1. Describe the modern manufacturing process with respect to productivity economic
2. Explain the trends in development of manufacturing process selection of suitable process for metal cutting and non-traditional manufacturing.

**Text Books:**

1. P.C Pandey and H.S. Shan, "Modern Machining Process", Tata Mc Graw – Hill Publishing Company Limited, New Delhi, 2007
2. V.K. Jain, "Advanced Machining Process", Allied Publishers Pvt Limited 2007.

**Reference Books:**

1. Amithaba Bhattacharyya, "New Technology", The Institution Of Engineers, India
2. HMT Bangalore, "Production Technology", Tata Mc Graw–Hill Publishing Company Limited, New Delhi, 2006.
3. Hassan El – Hofy "Advanced machining Processes" MC Graw-Hill, 2005.

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| **PEC-MST 415** | **Micro- and Nano-Fluidics** | **3L:0T:0P** | **3 Credits** |

**Course Objectives**

1. The general objective of this course is to introduce the students to the application of material science in the area of fluids.
2. Demonstrate to the students the superior thermophysical properties of micro and nanofluids.
3. Show through analytical and numerical analyses corroborated by experimental data that heat transfer systems will be smaller and will require less pumping power for the same amount of heat transfer using of micro and nanofluids, in comparison to conventional fluids used today.
4. Guide the students to research on this new topic to design modern mini and microchannel heat exchangers with micro and nanofluids exhibiting much higher thermal efficiency and saving energy.

**UNIT-I (12 hours)**

Introduction to microfluidics, continuum fluid mechanics at small scale, gas and liquid flows, Transport phenomena and related non-dimensional numbers, low Reynolds number flows, surface tension effects, electrokinetics, open surface microfluidics, fundamentals of nanofluidics, fluid flow

through nanoporous medium, multiphase flow.

**UNIT-II (12 hours)**

Synthesis of Nanofluids- two step methods- single step method- stability – Sonication- Colloidal stability - Electrical double layer- stabilization methods – steric stabilization - electrostatic stabilization – Surfactants- Types of surfactants – DLVO Theory- Methods of stability measurement - Dynamic light scattering system – Zeta potential – Acoustic Attenuation spectroscopy- Properties of nano fluids- thermal conductivity –viscosity – specific heat – Maxwell's relations- thermal conductivity models- wetting characteristics. Microscale Fluidic Applications.

**UNIT-III (12 hours)**

Fabrication techniques for microfluidics, photolithography, silicon based micromachining, polymer based micromachining, bonding techniques, wafer level assembly and packaging, flow characterization techniques, PIV technique, laser induced fluorescence and confocal microscopy, lab-on-a-Chip devices. Biomimetic micro and nanofluidics, surface wettability, smart materials, optofluidics, magnetofluidics, acoustic fluidics, microfluidic optical systems, capillary force actuators, microfluidic sensors, microfluidic valves, particle separation techniques at fluid-fluid interface, microneedles and micromixers, immobilization and detection of biomolecules, clinical diagnostics.

**UNIT-IV (12 hours)**

Application of nanofluids in refrigeration and air conditioning - Magnetic nano particles - Rheological fluids - Ferro fluids. Application of nanofluids in Lubricants – Types of lubricants – properties- Nano lubricant additives–solid lubricant additives – lamellar structure – synthesis and characterization - MoS2/WS2/graphene nanoparticles- Synthesis methods - Hydraulic assisted exfoliation – Friction and wear measurements – pin on disc –four ball tester. CO2 sequestration – absorption media – absorption mechanisms.

**UNIT-V (12 hours)**

Fuels – properties - Nano fuel additives – catalytic nano particles – synthesis and characterization - cerium – defects - cerium based mixed oxide nanoparticles – oxygen storage capacity –diesel engine exhaust emissions HC, CO, NOx, CO2, smoke - Diesel particulate filter -DPF regeneration, – Alumina in combustion process- Nanoparticle counters. Heterogeneous catalyst for trans esterification of biodiesel- Copper-oxide and Aluminum-oxide brake nanofluid- Electronics applications- Bio medical applications. Active and passive methods of enhancing heat transfer – Nanofluid – Heat exchangers – Nanofluid Coolant.

**Course Outcomes:**

On successful completion of the course, the students will be able to:

1. Apply the knowledge of material science in fluids and thermal engineering.
2. Design a system, component, or process to meet desired needs using micro and nanofluids.
3. Identify, formulate and solve fluid dynamic and thermal engineering problems involving material science.
4. Have the capability to carry out micro and nanofluid based research project. Understand the structure, properties and applications of specialty rubbers.
5. Understand the properties and applications of thermoplastic elastomers and ionomers.

**Text Books:**


1. Tabeling, P. Introduction to Microfluidics, Oxford, 2005.
2. Nguyen, Nam-Trung, Steven T. Wereley, and Steven T. Wereley. Fundamentals and applications of microfluidics. Artech house, 2002.
3. Nanofluids: Science and Technology, Sarit K. Das, Stephen U. Choi, Wenhua Yu, T. Pradeep,

Wiley, 2007.
4. Nanofluids: Synthesis, Properties and Applications, S M Sohel Murshed, Carlos Nieto de Castro, Nova Science Publishers, 2014.M, butyl rubber, nitrile rubber.

**Reference Books**

1. Heat Transfer Enhancement with Nanofluids, Vincenzo Bianco, OronzioManca, Sergio Nardini, KambizVafai, CRC Press, 2017.
2. Thermal Energy Storage Using Phase Change Materials: Fundamentals and Applications, Amy S. Fleischer, Springer, 2015.
3. Applications of Nanofluid for Heat Transfer Enhancement, Mohsen Sheikholeslami and Davood Domairry Ganji, Elsevier, 2017.

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| **PEC - MST 416** | **Semiconductor Materials and Devices** | **3L:0T:0P** | **3 Credits** |

**Course Objectives:**

1. To understand the basics of Semiconductors
2. To understand the basic electronic circuits and their operations.
3. To learn and use BJT and MOSFETs
4. To learn the basics of electronic devices such as transistors
5. To study the materials used in different semiconducting devices.

**UNIT-I: Fundamentals of Semiconductors (9 hours)**

Energy bands, Fermi level, energy- band models, direct and indirect band gap, electrons and holes, doping, intrinsic and extrinsic semiconductors, elemental and compound semiconductor, generation, recombination and injection of carriers, Drift and Diffusion of carriers, basic governing equations in semiconductors, Transport Equations

**UNIT-II: PN junction diode (9 hours)**

PN Junctions, Formation of Junction, Physical operation of diode, Contact potential and Space Charge phenomena, I-V Characteristics, Zener diode, Physical operation of special diodes (Tunnel diode, LED, OLED, Varactor diode and Photo Diode). Diode Applications - Rectifier circuits, Clipper and Clamper circuits, Photodiode and LED circuits.

**UNIT-III: Transistors – Basics (9 hours)**

Bipolar Junction Transistor: Device structure and physical operation, current – voltage characteristics. Field Effect Transistor (FET): MOS Capacitor: Device Structure and mode of operation, C- V Characteristics, Threshold Voltage.

**UNIT-IV: Transistor Circuits (9 hours)**

Bipolar Junction Transistor: DC Analysis of BJT Circuits, CB, CE and CC Configuration, Biasing BJT Circuits, Switch - Insulated Gate Bipolar Transistor (IGBT) – Characteristics of IGBT
Field Effect Transistor (FET): DC Analysis of MOSFET Circuits, biasing circuits

**UNIT–V: Materials for devices (9 hours)**

Silicon – Germanium - interface – II-VI semiconducting materials – III-V semiconductors – Materials for environmental applications – Bioimaging applications – Solar cell applications MOS diode - $SiO_2$ and High-k materials for MOS capacitors – Organic semiconducting materials.

**Course Outcomes:**

The students would be able

1. To understand basic semiconductor physics
2. To learn the basics of semiconductor devices such as diodes, transistors, FET, MOS capacitors.
3. To learn various materials used in semiconductor industry and their applications

**Text Books:**

1. Adel S. Sedra, Kenneth C. Smith & Arun N. Chandorkar, Microelectronic Theory and Applications, 2013, Fifth edition, Reprint, Oxford University press, New York, USA.
2. B G.Streetman and S.Banerjee, Solid State Electronic Education, 2015, Seventh edition, New Delhi, India.

**Reference Books:**

1. Jacob Millman, Christos C Halkias and Satyabrata Jit, Electronic devices and circuits, 2015,
2. Fourth edition, Tata Mc Graw Hill, New delhi, India.
3. Physics of Semiconductor Devices, S.M. Sze, 2nd Ed. Wiley, 1993, ISBN: 0852268467

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| PEC-MST 417 | Industrial Electrochemical Technology | 3L:0T:2P | 4 Credits |
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**Course Objectives**

1. To enable the students to gain knowledge in corrosion and its control
2. To enable the students to understand about batteries and Fuel Cells.
3. To learn the methodologies involved in electrometallurgy and electrochemicals.
4. To acquire knowledge in photo-electrochemical systems.

**UNIT-I: Corrosion and Its Control (12 hours)**

Basic aspects of corrosion - Importance of corrosion studies- EMF and Galvanic series- classification of corrosion- thories of corrosion- corrosion kinetics- Pourbaix diagram for Fe-$H_2O$ system – Passivation- High temperature corrosion. Forms of corrosion- Atmospheric corrosion- Biological and marine corrosion –Corrosion monitoring techniques. Cathodic Protection - Anodic protection – Corrosion inhibitors- Vapour phase Inhibitors-Green Inhibitors-Acidizing inhibitors.

**UNIT-II: Industrial Metal Finishing (12 hours)**

Principles of Electroplating- Metal deposition from solutions of simple and complex salts – measurement of current density, throwing power and current efficiency of electroplating bath – surface preparation for electroplating. Electroplating of Nickel and copper. Electroless plating and its advantages and limitations - Alloy plating of brass - Composite deposition –**Inorganic conversion coatings:** phosphating and chromating - Anodizing -Electro-polishing and its advantages.

**UNIT-III: Batteries and Fuel Cells (12 hours)**

**Primary Batteries:** Basic electrochemical reactions and performance characteristics of primary batteries such as Laclanche dry cell, Metal-air cells, Botton cells (Alk.$MnO_2$/Zinc, Mercury oxide cell and Li-cells; **Reserve batteries:** Water activated batteries such as Mg/AgCl and Mg/CuCl systems. **Secondary Batteries**: Lead acid, Ni-Cd, Ni-Metal hydride, Li-ion batteries; **Electrochemical supercapacitors**- EDLC, Pseudo, and hybrid supercapacitors. **Fuel Cells:** Proton exchange membrane fuel cells (PEMFC); Alkaline fuel cell, Phosphoric fuel cell and molten carbonate fuel cell, Direct methanol fuel cells (DMFC); Solid-oxide fuel cells (SOFC).

**UNIT–IV: Electrometallurgy and Electrochemicals (12 hours)**

**Elctro-hydrometallurgy:** Electrowinning - Electrorefinning – Electrolytic production of metal powders - Electroforming - Secondary metal recovery by electrochemical process - Electrochemical machining - Electrochemical Etching; **Elctro-pyrometallurgy:** Production of Mg, Al, Ca, Li, Na; **Electrochemicals:** Electrolytic synthesis of chlorates, perchlorates, hypochlorites - Chlor-alkali industry; Industrial elctroorganic process- Manufacturing of adiponitrile, Electrochemical fluorination of organic compounds. **Electropolymerization**: Electrochemical preparation of conducting polymers.

**UNIT-V: Photo-electrochemical systems (12 hours)**

Principles of photoelectrochemical cells - Types of photoelectrochemical cells- Organic photovoltaic cells, Dye sensitized solar cells, Quantum dots sensitized solar cells (QDSCs), Perovskite solar cell - Photoelectrocatalysts for waste water treatment and degradation of organic and organic compounds - Photoelectrocatalysts for hydrogen production.

**Course Outcomes:**

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

1. Understand corrosion and its control.
2. Acquire knowledge in batteries and Fuel Cells
3. Acquire knowledge in electrometallurgy and electrochemicals.
4. Understand photoelectrochemical systems.

**Industrial Electrochemical Technology Lab**

List of Experiments (Any 5 experiments are to be done)

1. Corrosion behaviour of metals in acid medium.
2. Draw the passivation curve of SS in $H_2SO_4$ medium
3. Electroplating of Ni
4. Electroless plating of Ni
5. Electroplating of brass
6. Electropolishing of SS
7. Anodization of Al (or) Ti
8. Fabrication Zn-ion battery and its performance studies.
9. Fabrication of Lead -acid battery and its performance studies.
10. Electrowinning of Ni from waste Ni plating bath.
11. Electropolymerization of PANI.
12. Fabrication of DSSC and its performance studies.

**Text Books:**


1. Bockris J.O & Reddy A.K.N. *Modern Electrochemistry* Vol. I, IIa, Vol. IIB, Plenum Publication, New York
2. Bokaris.J.O& Srinivasan.S.(1969). *Fuel Cells: Their Electrochemistry"*. McGraw Hill Book Company, New York
3. Tiwari.A, Hihara.L& Rawlins.J(2014). Intelligent coating for corrosion control, Elsevier Publishers, 1st Edn.
4. Allen J.Bard and Larry R. Faulkner, 2004, *Electrochemical methods: Fundamentals and Applications,* 2nd Edition John Wiley & Sons. Inc.
5. D. Linden Ed., (1995) , *Handbook of Batteries*, 2nd edition, McGraw-Hill, New York.
6. M.R. Rifi and F.H.Covitz, 1974, "*Industrial Electrochemistry*", Marcel Dekker Inc, New York
7. K.I.Popov, S.S.Djokic and B.N.Grgur,2002, *"Fundamentals of Electrometallurgy*", Kluwer Academic Publishing.

8. J.Bard & L.R.Faulkner,2001, *"Electrochemical methods-Fundamentals and Applications*" John Wiley & Sons, 3rd Edition.

**Reference Books**

1. Warren, S (1979) *Designing Organic Synthesis*, John Wiley & Sons, India.
2. G.A. Nazri and G. Pistoia, Lithium Batteries: Science and Technology, Kulwer Acdemic Publishers, Dordrecht, Netherlands (2004).
3. J. Larmine and A. Dicks, Fuel Cell System Explained, John Wiley, New York (2000).
4. Manthiram, (2000) *Science and Technology of Lithium Batteries-Materials Aspects: An Overview*, Kulwer Academic Publisher.
5. M. Wakihara, O. Yamamoto, (Eds.) (1998), *Lithium-ion Batteries: Fundamentals and Performance,* Wiley –VCH, Weinheim.

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| **PEC -MST 418** | **Materials for Clean Energy Conversion & Storage** | **3L:0T:2P** | **4 Credits** |

**Course Objective:**

To impart Fundamental understanding of the structure-composition-performance relationships of energy materials. Fabrication and evaluation of prototype clean energy conversion & storage devices (DSSC and Perovskite based solar cells, lithium batteries, supercapacitors, and fuel cells and hydrogen generation) Fabrication and evaluation of prototype clean energy conversion & storage devices (DSSC and Perovskite based solar cells, Hydrogen energy, lithium batteries, supercapacitors, and fuel cells)

**UNIT-1: Fundamental Concepts in Clean Energy Technologies (12 hours)**

Hydrogen Fuel, Chemistry of Electrocatalysis, Water electrolysis, Materials for Hydrogen Electrolyser and its economy, Basic Electrochemical Cell, Faraday's laws, Electrode Potentials, Thermodynamics of electrochemical cells, Polarization losses in electrochemical cells, Electrode process and kinetics, Electrical double layer, Photoelectrochemical cell, thermoelectric effect.

**UNIT-2: Nanomaterials for Energy Conversion Systems: Fuel Cells (12 hours)**

Issues and Challenges of functional Nanostructured Materials for electrochemical Energy, Conversion Systems, Fuel Cells, Principles and nanomaterials design for; Proton exchange membrane fuel cells (PEMFC); Direct methanol fuel cells (DMFC); Solid-oxide fuel cells (SOFC), current status and future trends.

**UNIT-3: Nanomaterials for Photovoltaic Solar Energy Conversion Systems (12 hours)**

Principles of photovoltaic energy conversion (PV), Types of photovoltics Cells, Physics of photovoltaic cells, Organic photovoltaic cell cells, thin film Dye Sensitized Solar Cells, Quantum dot (QD) Sensitized Solar Cells (QD-SSC), Organic-Inorganic Hybrid Bulk Hetero Junction (BHJ-SC) Solar cells, Perovskite solar cells, Current status and future trends.

**UNIT-4: Nanomaterials for Energy Storage (Li/Na Rechargeable Batteries) Systems (12 hours)**

Issues and Challenges of functional Nanostructured Materials for electrochemical Energy Storage Systems, Primary and Secondary Batteries (Lithium/ Sodium ion Batteries), Cathode and anode materials, Nanostructured Carbon-based materials, Nano-Oxides, Novel hybrid electrode materials, Current status and future trends.

**UNIT-5: Nanomaterials for Energy Storage (Super Capacitor) Systems (12 hours)**
Capacitor, Electrochemical supercapacitors, electrical double layer model, Principles and materials design, Nanostructured Carbon-based materials, Redox capacitor Nano- Oxides, conducting polymers-based materials, status and future trends.

**Course outcomes**:

After the completion of the course the students will be able to

1. Students will develop a comprehensive understanding of various clean energy conversion and storage technologies, including batteries, fuel cells, solar cells, and other relevant devices.
2. Students will identify and explain the specific material requirements for clean energy devices, considering factors such as conductivity, stability, and compatibility.
3. Gain a strong foundation in materials science principles, including structure-property relationships, phase transformations, and material characterization techniques.
4. Understand the materials used in battery technologies, including cathode, anode, and electrolyte materials, and their impact on battery performance.
5. Explore the materials employed in fuel cells, understanding the role of catalysts, membranes, and electrode materials in enhancing fuel cell efficiency.
6. Learn about the materials used in solar cells, including semiconductor materials and photoactive materials, and their contribution to solar energy conversion.

**List of Experiments (7 to be taken):**

1. Fabrication of Dye Sensitised Solar Cells
2. Fabrication of Perovskite Solar Cells
3. Electrochemical analysis and fabrication of Lithium Batteries- Coin cell (CR-2032)
4. Fabrication of Pouch cell of Lithium/Sodium Batteries
5. Fabrication of Lithium Capacitors
6. Fabrication of Sodium ion batteries- Coin cell (CR-2032)
7. Fabrication of Sodium capacitors
8. Fabrication of Super capacitors- Symmetric
9. Fabrication of Supercapacitors- Asymmetric
10. Fabrication of Fuel Cells- PEMFC

**Text Books:**


1. Electrochemical methods: Fundamentals and Applications, Allen J.Bard and Larry R. Faulkner, 2nd Edition John Wiley & Sons. Inc (2004)
2. D. Linden Ed., Handbook of Batteries, 2nd edition, McGraw-Hill, New York (1995)
3. G.A. Nazri and G. Pistoia, Lithium Batteries: Science and Technology, Kulwer Acdemic Publishers, Dordrecht, Netherlands (2004).
4. J. Larmine and A. Dicks, Fuel Cell System Explained, John Wiley, New York (2000).
5. Science and Technology of Lithium Batteries-Materials Aspects: An Overview, A. Manthiram, Kulwer Academic Publisher (2000).
6. M. S. Whittingham, A. J. Jacobson, Intercalation Chemistry, Academic Press, New York (1982).


**Reference Books:**


1. M. Wakihara, O. Yamamoto, (Eds.) Lithium Ion Batteries: Fundamentals and Performance, Wiley –VCH , Weinheim (1998).
2. Nanocomposites Science and Technology - P. M. Ajayan, L.S. Schadler, P. V. Braun.


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| PEC-MST 419 | Non-Destructive Techniques | 3L:0T:2P | 4 Credits |
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**Course Objectives:**
To provide a basic understanding with case studies on different surface NDE techniques and apply them for inspecting materials in accordance with industry specifications and standards.

**UNIT-1: Visual Testing (12 hours)**
Fundamentals of Visual Testing – vision, lighting, material attributes, environmental factors, visual perception, direct and indirect methods – mirrors, magnifiers, boroscopes and fibroscopes – light sources and special lighting – calibration- computer enhanced system – Employer defined applications, metallic materials including raw materials and welds – Inspection objectives, inspection checkpoints, sampling plan, inspection pattern etc – classification of indications for acceptance criteria - Codes, Standards and Specifications (ASME, ASTM, AWS etc.)

**UNIT-2: Liquid Penetrant Testing (12 hours)**
Principles – types and properties of liquid penetrants – developers – advantages and limitations of various methods - Preparation of test materials – Application of penetrants to parts, removal of excess penetrants, post cleaning – Control and measurement of penetrant process variables – selection of penetrant method – solvent removable, water washable, post emulsifiable – Units and lighting for penetrant testing –calibration- Interpretation and evaluation of test results - dye penetrant process-applicable codes and standards.

**UNIT-3: Magnetic Particle Testing (12 hours)**
Theory of magnetism – ferromagnetic, paramagnetic materials – characteristics of magnetic fields – magnetic hysteresis – magnetization by means of direct and alternating current – magnetic flux leakage - surface strength characteristics – Depth of penetration factors – Circular and longitudinal magnetization techniques, current calculation — field produced by a current in a coil, shape and size of coils, field strength, Magnetic Barkhausen Noise Analysis (MBN) – advantages and limitations,

**UNIT-4: Magnetic Particle Testing Equipment (12 hours)**
Selecting the method of magnetization, inspection materials, wet and dry particles – portable, mobile and stationary equipment – calibration- capabilities of equipment – magnetic particle inspection of castings and welding – Dry continuous method, wet residual method – Interpretation and evaluation of test indications – Principles and methods of demagnetization – Residual magnetism – applicable codes and standards.

**UNIT-5: Eddy Current Testing (12 hours)**
Basics of electromagnetics - Generation of eddy currents – effect of change of impedance on instrumentation – properties of eddy currents – eddy current sensing elements, probes, type of coil arrangement – absolute, differential, lift off, operation, applications, advantages, limitations – Through encircling coils, type of arrangements –absolute, differential fill factor, operation, application, advantages, limitations - Factors affecting sensing elements and coil impedance - test part and test system – Signal to noise ratio – equipment's, reference samples, calibration, inspection of tubes, cylinders, steel bars, welded tubing, plates and pipes, Remote Field Sensing - Interpretation/Evaluation –Applicable codes and standards.

**Course Outcome:**
After successful completion of this course the student will be able to: Have a basic knowledge of surface NDE techniques which enables to carry out various inspection in accordance with the established procedures. To calibrate the instrument and inspect for in-service damage in the

components. Differentiate various defect types and select the appropriate NDT methods for better evaluation. To communicate their conclusions clearly to specialist and non-specialist audiences. Finally, need to document the testing and evaluation of the results for further analysis. Understand how to read and understand specific Codes and Standards in each Technique.

**Text Books:**


1. ASM Handbook, Volume 17: Nondestructive Evaluation of Materials, ASM International (2018)
2. J. Prasad and C. G. K. Nair, Non-Destructive Test and Evaluation of Materials, Tata McGraw-Hill Education, 2nd edition (2017).
3. B. Raj, T. Jayakumar and M. Thavasimuthu, Practical Non Destructive Testing, Alpha Science International Limited, 3rd edition (2007).
4. T. Rangachari, J. Prasad and B.N.S. Murthy, Treatise on Non-destructive Testing and Evaluation, Navbharath Enterprises, Vol.3, (1983).
5. Ed. Peter.J. Shull, Nondestructive Evaluation: Theory, Techniques, and Applications, Marcel Dekker (2002).


***Reference Books and Standards:***


1. C. Hellier, Handbook of Non-Destructive Evaluation, McGraw-Hill Professional, 1st edition (2001).
2. J. Thomas Schmidt, K. Skeie and P. Maclntire, ASNT Non-Destructive Testing Handbook: Magnetic Particle Testing, American Society for Nondestructive Testing, American Society for Metals, 2nd edition (1989).
3. V. S. Cecco, G. V. Drunen and F. L. Sharp, Eddy current Manual: Test method, Vol.1, Chalk River Nuclear Laboratories (1983).
4. B.P.C. Rao, Practical Eddy Current Testing, Alpha Science International Limited (2006).
5. N. A. Tracy, P. O. Moore, Non-Destructive Testing Handbook: Liquid Penetrant Testing, Vol. 2, American Society for Nondestructive Testing, 3rd edition (1999).
6. Don E. Bray and Roderic K. Stanley, Nondestructive Evaluation: A Tool in Design, Manufacturing and Service, CRC Press (1996).
7. ASTM/ASME/API standards for Visual, Liquid Penetrant Testing, Magnetic particle Inspection and Eddy Current Testing


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| **PEC -MST 420** | **Advanced Nanobiotechnology** | **3L:0T:2P** | **4 credits** |

**Course Objectives:**

1. The course will provide necessary perspective towards biomaterials.
2. Understanding of interfacial interactions of synthetic and biological entities.
3. Impact of nanoparticles and their compatibility with biological models will be learned.
4. Advanced therapeutic modes and materials will be discussed.

**UNIT –I: Synthetic Materials in Medicine (9 hours)**

Properties of Materials: Bulk Properties of Materials, Surface Properties of Materials. Classes of Materials Used in Medicine: Structure and Properties of Metals, Ceramics, Glasses, and Glass-Ceramics, Polymers, Bioresorbable and Bi -erodible materials.

**UNIT–II: Biological Interactions with Materials (9 hours)**

Introduction, Biocompatibility, Cytotoxicity, Carcinogenicity, Interaction of Materials with Soft Tissues, Inflammation, Granulation Tissue Formation, Foreign Body Reaction, Fibrosis, Modification of Blood-Biomaterial Interactions, Cell Adhesion, Interactions with Hard Tissues.

**UNIT –III: Nanotoxicology (9 hours)**

Introduction, Toxicity of nanoparticles, Types of Nanoparticles causing Toxicity, Target organ toxicity, Exposure, Uptake, and Barriers, Experimental Models in Nanotoxicology-Predicting Penetration and Fate of Nanoparticles in the Body.

**UNIT –IV: Tissue engineering (9 hours)**

Introduction, Stem cells, Morphogenesis, Generation of tissue in the embryo, Tissue homeostasis, Cellular signalling, Extracellular matrix as a biologic scaffold for tissue engineering, Natural polymers in tissue engineering applications, Degradable polymers for tissue engineering, Degradation of bioceramics.

**UNIT –V: Drug Delivery Systems (9 hours)**

Fundamentals of Drug Nanoparticles: Production, Size, Surface area, Suspension and Settling, Magnetic and Optical Properties, Biological Transport. Delivery of Nanoparticles: Brain Delivery, Ocular Drug Delivery, Carriers in Cancer Therapy, Cardiovascular System, Vascular Delivery to the Lungs.

**Course Outcomes:**

An understanding of the nano regime of biological entities and their analytics will be gained by students.

**List of Experiments to conduct Laboratory**

1. Development of bioceramics coating on metallic implants
2. Test methods for the evaluation of cytotoxicity of Biomaterials
3. Test methods for the evaluation of Bioactivity of Biomaterials
4. Methodology to analyse the antibacterial efficacy of Biomaterials
5. Development of porous scaffolds for Bone tissue engineering
6. Protocols to analyse the drug release capability of Biomaterials
7. Test methods to evaluate the Protein interaction with Biomaterials
8. Test methods for the evaluation of Blood-Biomaterial interaction

**Text books**


1. BlOMATERIALS SCIENCE, An Introduction to Materials in Medicine, Edited by Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, Academic Press, A division of Harcourt Brace & Company, 525 B Street, Suite 1900, San Diego, California 92101-4495, USA.
2. The Chemistry of Medical and Dental Materials, John W. Nicholson, RSC MATERIALS MONOGRAPHS, Published by The Royal Society of Chemistry, Thomas Graham House, Science Park, Milton Road, Cambridge CB4 OWF, UK. ISBN 0-85404-572-4.
3. Tissue Engineering, Clemens van Blitterswijk, Peter Thomsen, Anders Lindahl, Jeffrey Hubbell, David Williams, Ranieri Cancedda, Joost de Bruijn, Jérôme Sohier, Academic Press, Elsevier, 84 Theobald's Road, London WC1X 8RR, UK, 30 Corporate Drive, Suite 400, Burlington, MA 01803, USA, 525 B Street, Suite 1900, San Diego, CA 92101-4495, USA, 2008 ISBN: 978-0-12-370869-4.
4. Nanofabrication towards Biomedical Applications, Techniques, Tools, Applications, and Impact. C. S. S. R. Kumar, J. Hormes, C. Leuschner, 2005, WILEY -VCH Verlag GmbH & Co. KGaA, Weinheim, ISBN-13 978-3-527-31115-6, ISBN-10 3-527-311157.

5. Nanoscale Technology in Biological Systems, Edited by Ralph S. Greco, Fritz B. Prinz, R. Lane Smith, CRC PRESS, Boca Raton London New York Washington, D.C. Copyright © 2005 by Taylor & Francis
6. Nanoparticulates Drug Carriers, Edited by VLADIMIR P TORCHILIN, 2006, Imperial College Press, 57 Shelton Street, Covent Garden, London WC2H 9HE, ISBN 186094-630-5.

**References:**

1. Gerald Karp, "Cell and Molecular Biology", Fifth Edition, John Wiley, 2008.
2. Materials Science and Engineering – An Introduction, William D Callister, 12th Edition, John Wiley .
3. Nanomaterials – An introduction to synthesis, properties and applications, D. Vollath, Wiley-VCH, Second Edition 2013.
4. Malcolm Rowland, Thomas Tozer, "Clinical Pharmacokinetics and Pharmacodynamics, Concepts and Applications", 4th Edition, WoltersKluver, 2011.
5. Drug Delivery Systems, Third Edition, Vasant V Ranade, John B. Cannon, by CRC Press, 2011

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| PEC -MST 421 | Industrial Nanotechnology | 3L:0T:0P | 3 Credits |
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## Course Objective:

The course provides knowledge on Nanotechnology in various industries such as agricultural, food, textiles and cosmetics, chemical and electrochemical industries and Defence. Besides that, Nanotechnology in environmental and health issues.

**UNIT- I: Agriculture industry (12 hours)**

Precision farming, Smart delivery system – Insecticides using Nanotechnology – Nano fertilizers - Nanofertigation - Nano-seed Science. **Food industry:** Nanopackaging for enhanced shelf life - Smart/Intelligent packaging - Food processing and food safety and bio-security –Electrochemical sensors for food analysis and contaminant detection.

**UNIT- II: Textiles Industry (12 hours)**

Production of Nano-woven fibers from electrospinning – Controlling parameters and morphologies of nanofibers – Nanocomposite fibres; Nanofinishing **in textiles:** UV resistant, anti-bacterial, hydrophilic, self-cleaning, Flame retardant finishes; **Modern textiles**: Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof clothes. **Cosmetics Industry:** Formulation of Gels, Shampoos, Hair-conditioners (Micellar self-assembly and its manipulation) – Sun-screen dispersions for UV protection using titanium oxide – Anti-aging cream - Colour cosmetics.

**UNIT-III: Nanotechnology in Chemical and Electrochemical Industries (12 hours)**

Nanocatalysts – Nanoporous Zeolites – Nanoreactors – Solid lubricants – Nanotechnology in Electrometallurgy, Electroplating and Organic coatings – Electrolytic production of metal nanopowders, Electrochemical exfoliation for the production of Graphene and other metal chalcogenides – Electrochemical synthesis of Nanostructured materials including conducting polymers.

**UNIT-IV: Nanotechnology in Defence (12 hours)**

Military applications of Nanotechnology –Nano-Battle suit – Nano-drones – Nano- Satellites – Nano-Propellants and Explosives – Camouflage distributed sensors - Amour protection - Implanted Nano-

systems - Mini-/Micro robots - Small satellites and Space launchers –Nano- Nuclear,Chemical & Biological weapons.

**UNIT- V: Nanotechnology in Environmental and Health Issues (12 hours)**

Nano-adsorbents and photocatalysts for water and wastewater treatment – Nanomaterials for adsorption of heavy metals – Nanoparticles for degradation of sovents and organic compounds – Nanomembranes in drinking water and air/gas purification – Environmental impacts of Nanomaterials on human and animal health – Safety issues and regulatory practices in handling Nanomaterals – Toxicity of nanoparticles, Effect of inhaled nanoparticles and skin exposure to nanoparticles - Impact of CNTs on respiratory systems; Environmental hazards in processing of Nanoparticles – Emerging issues of nano/microplastics.

**Course Outcomes:**

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

1. Understand the influence of Nanotechnology in various industries and Defence.
2. Acquire knowledge about Nanotechnology in environmental and health issues.

**Text Books:**


1. J. Altmann, Routledge, Military Nanotechnology: Potential Applications and Preventive Arms Control, Taylor and Francis Group, 2006.
2. Jennifer Kuzma and Peter VerHage, Nanotechnology in agriculture and food production, Woodrow Wilson International Center, (2006).
3. Lynn J. Frewer, Willehm Norde, R. H. Fischer and W. H. Kampers, Nanotechnology in the Agri-food sector, Wiley-VCH Verlag, (2011).
4. P. J. Brown and K. Stevens, Nanofibers and Nanotechnology in Textiles, Woodhead Publishing Limited, Cambridge, (2007).
5. Q. Chaudry, L.Castle and R. Watkins Nanotechnologies in Food, RSC Publications, 2010.
6. K.I.Popov, S.S.Djokic and B.N.Grgur, Fundamentals of Electrometallurgy, Kluwer Academic Publishing 2002.
7. A.J.Bard & L.R.Faulkner, Electrochemical methods -Fundamentals and Applications John Wiley & Sons, 3rd Edition, 2001.


**Reference Books:**


1. Y-W. Mai,Polymer Nano composites, Woodhead publishing, (2006).
2. Udo H. Brinker, Jean-Luc Mieusset (Eds.), Molecular Encapsulation: Organic Reactions in Constrained Systems,Wiley Publishers (2010).
3. Nanocomposites Science and Technology - P. M. Ajayan, L.S. Schadler, P. V. Braun.
4. .E.Raub &K.Muller, Fundamentals of Metal deposition, Elseiver publishing Co, New York, 1967.
5. P. Brown and K. Stevens, Nanofibers and Nanotechnology in Textiles, Woodhead publication, London, 2006.


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# Honors in Materials Science and Technology
## Honors Course Basket [HCB]

*(Minimum 06 courses to be taken; The students who opting to take Honors Degree must acquire minimum 20 or 21 credits. Registration is Mandatory on the 3th Semester)*

| Sl. | Code No. | Subject | Semester | Credits |
|---|---|---|---|---|
| 1 | HC -MST 201 | Computational Methods in Engineering | 3/**4** | 4 |
| 2 | HC - MST 202 | Additive Manufacturing | 3/**4** | 4 |
| 3 | HC - MST 203 | Iron and Steel Making | 3/**4** | 3 |
| 4 | HC-MST 204 | Magnetic Materials and Devices | 3/4 | 3 |
| 5 | HC -MST 305 | Nanoelctronics and Nanophotonics | 5/6 | 3 |
| 6 | HC-MST 306 | Mechanical Behaviour of Materials | 5/6 | 3 |
| 7 | HC-MST 307 | Micro-Electro Mechanical Systems (MEMS) | 5/6 | 3 |
| 8 | HC-MST 308 | Surface Engineering | 5/6 | 3 |
| 9 | HC-MST 309 | Electrochemical Process Technology | 5/6 | 3 |
| 10 | HC – MST 410 | Thin Film Technology | 7/8 | 4 |
| 11 | HC - MST 411 | Sensor Materials and Technologies | 7/8 | 3 |
| 12 | HC - MST 412 | Extractive and Powder Metallurgies | 7/8 | 3 |
| 13 | HC - MST 413 | Rubber Technology | 7/8 | 3 |
| 14 | HC – MST 414 | Modern Manufacturing Process | 7/8 | 3 |
| 15 | HC - MST 415 | Micro- and Nano-Fluidics | 7/8 | 3 |
| 16 | HC - MST 416 | Semiconductor Materials and Devices | 7/8 | 4 |
| 17 | HC - MST 417 | Industrial Electrochemical Technology | 7/8 | 4 |
| 18 | HC - MST 418 | Materials for Clean Energy Conversion & Storage Devices | 7/8 | 4 |
| 19 | HC- MST 419 | Non-destructive Techniques | 7/8 | 3 |
| 20 | HC - MST 420 | Advanced Nanobiotechnology | 7/8 | 4 |
| 21 | HC–MST 421 | Industrial Nanotechnology | 7/8 | 3 |
| | | | **Total Credits:** | **21** |

***MST-Materials Science and Technology, EE –Energy Engineering, CST-Computer Science and Engg., ECE-Electronics and Communication Engg., etc.***

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| **For Course Codes: HC -MST 201 to HC -MST 203** | **Refer Professional Elective Course syllabus** |

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| **For Course Codes: HC -MST 410 to HC -MST 421** | **Refer Professional Elective Course syllabus** |

| HC -MST 204 | Magnetic Materials and Devices | 3L:0T:0P | 3 Credits |
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**Course Objectives:**

1. To provide the basic concepts of magnetism and magnetic materials
2. To explain the Giant magneto resistance and its applications in magnetic memories
3. To explain the theory of electromagnetism and its applications
4. To impart knowledge about the nanomagnetic devices and bioapplications

**UNIT-I: Basics of Magnetism (9 hours)**

Basic concepts of magnetism, origin of magnetism, magnetic flux, magnetization, magnetic induction, susceptibility and permeability, Diamagnetism, Paramagnetism, Ferromagnetism, Anti-ferromagnetism and Ferrimagnetism, Curie law and Curie-Weiss law, Pauli paramagnetism, Domains and Hysteresis, Soft and Hard magnetic materials, magnetostriction, magnons

**UNIT-II: Giant magnetoresistance (9 hours)**

Introduction to spintronics, magnetoresistance in normal metals, MR ratios, Giant magnetoresistance in ferromagnetic multi layers and superlattices, co-operative phenomena and magnetization reversal, applications in spin valve and read heads, comparison of GMR and AMR, oscillation of coupling energy, non-coupling type GMR, CPP and CIP GMR, GMR in nanograins, mechanism of GMR.

**UNIT-III: Tunnel Magneto resistance and Ballistic magnetoresistance (9 hours)**

Tunnel magnetoresistance: ferromagnetic tunnel junctions, phenomenological theory of TMR, MR ratio and spin polarization, factors influencing TMR, MR ratio for Fe/MgO/ Fe system, oscillations in TMR, tunnel junctions with manganites, Heusler alloys, Coulomb blockade in tunnel junctions. Ballistic magneto resistance: conductance quantization in quantum confined semiconductors, metals. Anisotropic magnetoresistance, media for high density recording, magnetic sensors,

**UNIT-IV: Nanobiomagnetism (9 hours)**

Magnetic targeting, magnetic separation and detection, magnetic tweezers, drug and gene delivery, chemotherapy, MRI, magnetic contrast agents, hyperthermia, application of various nanomagnetic materials in biotechnology, superparamagnetism, core-shell structures and their applications, iron oxide and novel Nanomaterials.

**UNIT-V: Electromagnetism (9 hours)**

Basics of Electromagnetism: Electric flux density – Gauss's law and Divergence – Basic concept of Stoke's theorem and Divergence theorem, Basic laws of electricity and magnetism –Biot Savart law, Amperes Circuital law, Faradays law, Continuity equation for current density, Displacement current, Maxwell equations in integral and differential form, Poynting vector and Poynting theorem.

**Course Outcomes:**

On successful completion of this course, the students will able to

1. Understand the basics of magnetism and magnetic properties
2. Acquire knowledge on principle and operation of various magnetic devices.
3. Acquire knowledge on utilization of various nanostructures for fabrications of advanced magnetic devices, like GMR, TMR, BMR devices.

**Text Books:**


1. Physics of Magnetism and Magnetic Materials, K.H.J Buschow, F.R. de Boer, Springer, 2003,
2. Introduction to Magnetic Materials, B. D. Cullity, Wiley, 1972,
3. Magnetism in the Solid State, Peter Mohn, Springer series in solid-state sciences, 2006,

4. Nanomagnetism and Spintronics, Teruyo Shinjo Elsevier, 2009
5. Spintronics: Fundamentals and Applications, Puja Dey, Jitendra Nath Roy, Springer 2021
6. Spintronics: Fundamentals and Applications, I. Zutic and S. D, Sarma, Rev. Mod. Phys, 76, 323 (2004).
7. Engineering Electromagnetics W H Hayt, J A Buck and M J Akhtar, McGraw Hill, 8 Ed, 2017
8. A Student's Guide to Maxwell's Equations, Daniel Fleisch, Cambridge University Press, 2008
9. Electromagnetic Waves and Radiating Systems - E.C. Jordan and K. G. Balmain, 2nd Ed., 2000, Prentice Hall Inc.

**Reference Books:**

1. Magnetism – Fundamentals, Edited by E. du Tremolet de Lacheisserie, D. Gognoux, M. Schlenker, Springer, 2003
2. Elements of Electromagnetics - Matthew N. O. Sadiku, 4th., Oxford Univ. Press.
3. Advanced Magnetic Nanostructures, Ed. D. Sellmyer, R. Skomski, Springer, 2009,
4. Nanostructured Magnetic Materials and their Applications, Ed. D. Shi, B. Aktas, L. Pust, F.Mikailov, Springer, 2002,
5. Advances in Nanoscale Magnetism, Ed. B. Aktas, F. Mikailov, Springer, 2009,
6. Handbook of Thin Film Materials, Volume 5, Edited by H.S Nalwa, American Scientific Publishers, 2002,
7. Encyclopedia of Nanoscience and Nanotechnology, Edited by H.S. Nalwa, American Scientific Publishers, 2007.

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| **HC -MST 305** | **Nanoelectronics and Nanophotonics** | **3L:0T:0P** | **3 Credits** |

**CoCourse objectives:**

1. To provide basic concepts of nanoelectronics and nanophotonics
2. To prove the principle of operation of various electronics like FET, LED, MOSFET,
3. To provide the theory of photonic devices such as quantum well lasers

**UNIT-I: LEDs and Semiconductor Lasers (9 hours)**

Fundamentals of Semiconductor physics, Review of quantum confinement theory, optical phenomena in various quantum structures: quantum wells, quantum wires, quantum dots, superlattices. GaAs/ GaAlAs quantum well lasers, quantum wire lasers, quantum dot lasers, white light LEDs, vertical cavity surface emitting lasers, quantum cascade lasers, quantum well infrared detectors, digital logic based on quantum wells, GaN and other visible LEDs, semiconductor lasers.

**UNIT II: Photonic Crystals (9 hours)**

Definition of 1-, 2- and 3-D photonic crystals – Bragg Mirror – Yablonovite structure - Fabrication – 1-D Phototonic crystal by sputtering method – 2-D photonic crystal by Biomineralization – 2-D photonic crystals by Microfabrication– 3-D photonic crystals by Self-assembly – Colloidal crystals by Sedimentation – Convective Self-assembly of Opaline thin films - Photonic Crystals with Tunable Properties.

**UNIT-III: Nano biophotonics (9 hours)**

The interface of bioscience, nanotechnology and photonics - Semiconductor quantum dots for bioimaging – Quantum confinement – Size dependent band gap – Advantages – Major issues and solution – Metallic nanoparticles for Biosensing - Surface plasmon resonance – Localized SPR – SPR based sensor using Au nanoparticles – Up-converting nanophores - Nanoparticles for Upconversion – Pebble nanosensors for Invitro Bioanalysis - Nanoclinics for optical diagnostics and Targeted therapy – Hyperthermic effect.

**UNIT-IV: Nanoscale MOSFETs (9 hours)**

Challenges in miniaturization, quantum effects, thin oxides, random dopant fluctuations, tunneling and subthreshold currents, power density, hot electron effects, fundamental limits of MOS operations, MODFET (Modulation Doped FET), GaN based HEMT (High Electron Mobility Field Effect Transistors).

**UNIT-V: Molecular Nanoelectronics (9 hours)**

Single molecular devices, Molecular nanowires, charge transport in organic materials, fabrication techniques for molecular electronics, organic LEDs, organic FETs, carbon nanotube and grapheme based FETs, Silicon nanowire based FETs, **Single Electron Tunneling Phenomena and Devices :** Single electron tunneling, charging energy, tunneling rates, single electron transistor, Coulomb blockade, Coulomb staircase, Bloch oscillations, negative differential resistance, resonant tunneling diode and resonant tunneling transistor.

**Course Outcome:**

On completion of the course the students will be able to gain knowledge about the important concepts of nanophotonics, quantum well lasers, nanoelectronics and biophotonics.

**Text Books:**

**Nanophotonics**


1. Introduction to Nanophotonics, Sergey V. Gaponenko, Cambridge University Press, New York, ISBN-13 978-0-521-76375-2 (2010)
2. Photonic crystals: Physics and Technology, (Eds.) C. Sibilia, T. M. Benson, M. Marciniak, T. Szoplik, (ISBN: 978-88-470-0843-4) (2008)
3. Photonic Crystals (2nd edition), John D. Joannopoulos, Steven G. Johnson, Joshua N. Winn, Robert D. Meade, Princeton University Press, ISBN: 978-0-691-12456-8 (2008)
4. Principles of Nanophotonics, Motoichi Ohtsu, et al. ISBN : 13: 978- 1- 58488- 972- 4, by Taylor & Francis Group, LLC (2008) .


**Nanoelectronics**


1. Nanoscale Transistors- Device Physics, Modeling and Simulation, M. Lundstrom, J. Guo, Springer, 2005, ISBN- 978-0-387-28003-5, 978-0-387-28002-8, 978-1-4419-3915-9.
2. Nanoelectronics- principles and devices, M. Dragoman and D. Dragoman, Artech House publishers, 2005, ISBN: 9781596933682.
3. Fundamentals of modern VLSI devices, Y. Taur and T. H. Ning, Cambridge University Press, 1998, ISBN: 0521559596, 9780521559591.
4. Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum Devices, K. Goser, P. Glosekotter and J. Dienstuhl, Springer, 2005, ISBN 978-3-662-05421-5.
5. Handbook of Thin Film Materials, volume 5, edited by H.S Nalwa, American Scientific Publishers, 2002, ISBN: 9780125129084, 9780080533247.

6. Nanoelectronics and Information Technology, W. Rainer, Wiley, 2003, ISBN: 978-3-527- 40927-3

**Reference Books:**

1. Overview of Nanoelectronic Devices, D. Goldhaber Gordon, Proceedings of IEEE, volume 85, 1997.
2. Encyclopedia of nanoscience and nanotechnology, Edited by H.S. Nalwa, American Scientific Publishers, 2007, ISBN: 1-58883-001-2 , ISBN: 1-58883-159-0.
3. Introduction to Biophotonics, Paras N. Prasad, (John Wiley and Sons, New Jersey), ISBN: 0-471-28770-9 (2003)
4. Photonic Crystals:Towards Nanoscale Photonic Devices, J.-M. Lourtioz, H. Benisty, V. Berger, J.-M. Gerard, D. Maystre, A. Tchelnokov, ISBN-13 978-3-540-24431-8, Springer-Verlag Berlin Heidelberg (2005)
5. Nanosystems, K.E. Drexler, Wiley, 1992, ISBN:0-471-57518-6
6. Advances In Biophotonics, (Eds.) Brian C. WilsonValery V. Tuchin and Stoyan Tanev, IOS Press, ISBN 1-58603-540-1, (2005)
7. Biophotonics, Optical Science and Engineering for the 21st Century, (Ed.) Xun Shen and Roeland Van Wijk, ISBN-10: 0-387-24995-8; ISBN-13: 978-0387-24995-7; eISBN: 0- 387-24996-6
8. Nano Biophotonics: Science and Technology, (Eds) Hiroshi Masuhara, Satoshi Kawata, F. Tokunaga, ISBN-13: 978-0-444-52878-0; ISBN-10: 0-444- 52878-4, Elsevier (2007)

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| **HC- MST 306** | **Mechanical Behaviour of Materials** | **3L:0T:0P** | **3 Credits** |

**Course objectives:**

1. To enable the student to understand the relation between structure and material properties
2. To design and improve the mechanical properties of materials

**UNIT-I: Elastic and Plastic Properties (9 hours)**

Introduction to crystal structure and bonding – correlation of physical and mechanical properties – Normal and Shear stress - Elastic and Plastic behaviour of materials - Hooke's law, plastic behaviour: dislocation geometry and energy, dislocation mechanics, slip system - Burger's vectors and dislocation loops, dislocations in the FCC, HCP and BCC lattice – plastic deformation in amorphous, single and polycrystalline materials,

**UNIT-II: Strengthening Mechanisms (9 hours)**

Solid solution strengthening, Grain boundary strengthening, Particle hardening, precipitation strengthening, dispersion strengthening, fibre strengthening - Yield point phenomenon, strain aging and dynamic strain aging

**UNIT-III: Fracture and Fracture Mechanics (9 hours)**

Types of fracture, fracture in ductile material, brittle fracture, Griffith's criteria, Orowan's modification. Izod and Charpy Impacts tests, Ductile to Brittle Transition Temperature (DBTT), Factors affecting DBTT, determination of DBTT. Fracture mechanics-introduction, modes of fracture, stress intensity factor, strain energy release rate, fracture toughness and determination of KIC, introduction to COD, J integral.

**UNIT-IV: Fatigue Behaviour and Testing (9 hours)**

Fatigue of engineering materials - Characteristics of fatigue fracture -Fatigue crack propagations laws, S-N curves, effect of mean stress, factors affecting fatigue, structural changes accompanying fatigue, cumulative damage, HCF / LCF, thermomechanical fatigue, application of fracture mechanics to fatigue crack propagation, fatigue testing.

**UNIT-V: Creep Behaviour and Testing (9 hours)**

Creep, mechanisms of creep, structural changes during creep, Creep curve, stages in creep curve and explanation, creep mechanisms, metallurgical factors affecting creep, Creep of pure metals, solid solutions, MMCs, Creep of ceramics and polymers, creep testing, parametetric methods of extrapolation. Deformation Mechanism Maps, superplasiticity in materials

**Course Outcome:**

After the end of the course the student has the ability

1. To understand the mechanism involved in elastic and plastic behaviour of metals
2. To know about the role of grain boundaries on mechanical properties
3. To apply their knowledge for the modification of strength of materials
4. To understand the fracture and testing
5. To know about strength of materials at high temperatures

**Text Books:**


1. Robert E. Reed-Hill, Physical Metallurgy Principles, 2nd Editions, East-West Press Pvt. Ltd, New Delhi, 2008.
2. Donald R. Askeland and Pradeep P. Phule, The Science and Engineering of Materials, 4th Eds, Thomson, Singapore, 2003.
3. Dieter, G.E., Mechanical Metallurgy, McGraw-Hill, SI Edition, 1995.
4. Davis. H. E., Troxell G.E., Hauck.G. E. W., The Testing of Engineering Materials, McGrawHill, 1982.


**References:**


1. Mechanical Behavior of Materials: Thomas H. Courtney, 2nd Ed., Waveland Press Inc., 2005.
2. Deformation and Fracture Mechanics: R.W. Hertzberg, R.P. Vinci, J.L. Hertzberg, 5th Ed., Wiley, 2012.
3. Hayden, H. W. W. G. G. Moffatt, J. Moffatt and J. Wulff, The Structure and Properties of
4 Materials, Vol.III, Mechanical Behavior, John Wiley & Sons, New York, 1965.
4. Introduction to Dislocations: D. Hull and D.J. Bacon, Butterworth-Heinemann, Elsevier, 2011.
5. Honey combe R. W. K., "Plastic Deformation of Materials", Edward Arnold Publishers, 1984.
6. Wulff, The Structure and Properties of Materials, Vol. III "Mechanical Behavior of Materials", John Wiley and Sons, New York, USA, 1983.


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| **HC -MST 307** | **Micro Electro Mechanical Systems (MEMS)** | **3L:0T:0P** | **3 Credits** |

**Course Objectives:**

1. To provide a comprehensive perspective on various materials and fabrication processes used in microfabrication
2. Understand fundamental principles of sensing and actuation and corresponding scaling laws in MEMS
3. To create an understanding on the principle, design, and fabrication techniques of MEMS devices used various industries
4. Understanding the basic design concepts in MEMS

**UNIT- I: Introduction to MEMS Technology (9 hours)**

Overview of MEMS and Microsystems – Thin film growth and models –Mechanical, Electrical, Thermal properties for Thin Films/MEMS –Measurement techniques – Materials for MEMS-Semiconductors, Metals and Metal alloys, Ceramics, Polymers – Silicon and other substrate materials.

***UNIT- II: Processing of MEMS/NEMS (9 hours)***

Silicon processing, Structure & properties – Single crystal growth - Overview of Lithographic process – Additive processes for Semiconductors, Ceramics, Metals and polymers - MEMS Fabrication – Doping process - Bulk micromachining - Wet & Dry Etching- Isotropic and anisotropic etching and mechanism - Etch stop techniques – DRIE and other processes- Surface Micromachining – LIGA and laser assisted processing – Nanomechanical system fabrication - Fundamentals of Design and Simulation.

***UNIT- III: Device Integration: Interconnects (9 hours)***

Requirements of interconnects –Metallization Techniques — Damascene process- silicide and refractory metals - Multilevel and nanostructured interconnects – Bonding Techniques. **Packaging and Failure:** Packaging Fundamentals – Packaging Techniques– Electrical and thermal requirements - Packaging Reliability and failure modes and analysis – MEMS process integration- Tribological issues

***UNIT- IV: Engineering Mechanics (9 hours)***

Microsystem design – Static bending of thin films –Mechanical vibration– thermo mechanics– fracture mechanics – Thermofluidics - Scaling laws in miniaturization

***UNIT- V: Micro Sensors and Actuators (9 hours)***

Mircosensors and Microactuators– Optical, chemical, thermal, gas, pressure, bio and mechanical sensors – Nanosensors– RF and BioMEMS- Applications in automobile, aerospace, health care, industrial, consumer and telecommunications

**Course Outcomes:**

At the end of the course, students should have the gained the ability to:

1. Understand the role of MEMS technology in daily lives as well as in advanced technologies
2. Design of various MEMS components and knowledge to integrate into a device
3. End product based selection of materials and design of processes
4. A comprehensive understanding to fulfill the requirements of industrial sector.

***Text Books:***


1. Marc Madou J, Fundamentals of Microfabrication, Second Edition, CRC Press, Boca Raton, 2002, ISBN: 0-8493-0826-7.
2. Nadim Maluf and Kirt Williams, An introduction to Micro electro mechanical systems Engineering, Second Edition – Artech House, Inc., Boston, 2004, ISBN: 1-58053-590-9.
3. Tai-Ran Hsu, MEMS and Microsystems – Design, Manufacture, and Nanoscale Engineering, Second Edition, John Wiley & Sons, Inc., New Jersey, 2008, ISBN: 978-0- 470-08301-7.
4. Chang Liu, Foundations of MEMS, Pearson, 2011, ISBN-13: 978-0-13-249736-7


***Reference Books:***


1. Stephen D. Senturia, Microsystem Design, Kluwer Academic Publishers, 20
2. Reza Ghodssi, Pinyen Lin, MEMS Materials and Processes Handbook, Springer, New York,

2011, ISBN: 978-0-387-47316-1.
3. Sami Franssila, Introduction to Microfabrication, Second Edition, John Wiley & Sons, Sussex, 2010, ISBN: 978-0-470-74983-8.
4. Francisco J. Arregui, Sensors based on nanostructured materials, First Edition, Springer- Verlag, New York, 2009, ISBN: 978-0-387-77752-8.
5. Bharath Bhushan, Springer Hand Book of Nano Technology, Third Edition, Springer- Verlag, New York, 2010, ISBN: 978-3-642-02524-2.
6. Sergey Edward Lysherski, MEMS and NEMS Systems, devices, and structures, First Edition, CRC Press, Boca Raton, 2002, ISBN: 9780849312625.
7. H. Baltes, O. Brand, G. K. Fedder, C. Hierold, J. G. Korvink, O. Tabata, Enabling Technology for MEMS and Nanodevices, Wiley-VCH, Weinheim, 2013, ISBN: 978-3- 527-33498-8.
8. Danny Banks, Microengineering, MEMS, and Interfacing - A Practical Guide, Taylor & Francis, Boca Raton, 2006, ISBN: 978-0-8247-2305-7.
9. C.P. Wong, Kyoung-Sik (Jack) Moon, Yi Li, Nano-Bio- Electronic, Photonic and MEMS Packaging, Springer, New York, 2010, ISBN: 978-1-4419-0039-5.
10. Sandra Carrara, Nano-Bio-Sensing, Springer, New York, 2011, ISBN: 978-1-4419-6169-3.

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| HC -MST 308 | Surface Engineering | 3L:0T:0P | 3 Credits |
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**Course Objectives:**

To teach the students

1. On the importance of Surface Engineering for various industrial applications
2. To understand the properties of surface & its interactions with its environment
3. On the methods various surface modification techniques
4. To evaluate and inspect the surface modified materials for various industrial usages.

**UNIT-I: Introduction to Surfaces (9 hours)**

Surfaces– Surface dependent properties and failures – Chemical, Mechanical and Geometrical-Thermodynamics of surfaces – surface energy –Surface Engineering: classification, definition, scope and general principles – Overview of Surface Characterization Techniques

**UNIT-II: Tribological Aspects of Surfaces (9 hours)**

Tribological aspects of adhesion, friction and wear – Friction and Friction Types – Theories of Macro and Nanoscale friction–Wear – Wear Mechanisms and types – identification of different mechanisms – Wear theory– Characterization techniques for friction and wear –Methods to reduce wear and Friction –Lubrication –Surface Coatings

**UNIT-III: Surface Modifications (10 hours)**

Concept and importance, classification of surface modification techniques, advantages and their limitations. Surface metallurgy: Localized surface hardening (flame, induction, laser, electron beam hardening, Laser melting, shot peening). Surface chemistry: Phosphating, Chromating, Electrodeposition, Electrochemical conversion coating, Carburizing, Nitriding, Ion implantation, Laser alloying, boriding, Organic coatings, Ceramic coatings

**UNIT-IV: Advanced surface coating techniques (8 hours)**

Gaseous State (CVD, PVD etc), Solution State (Chemical solution deposition, Electrochemical deposition, Sol gel, electroplating), Molten or semimolten State (Laser cladding and Thermal spraying), General design principles related to surface engineering, design guidelines for surface preparation

**UNIT- V: Evaluation of surfaces (9 hours)**

Surface Characterization (physical and chemical methods, XPS, AES, RAMAN, FTIR etc), Structural Characterization, Mechanical Characterization (Adhesion, Hardness, Elastic Properties, Toughness, Scratch and Indentation etc.), Tribological Characterization - Standards for measurement of surface treated materials – depth – thickness – hardness and friction co-efficient.

**Course Outcome:**

After studying this course, the student should be

1. able to engineer the surface towards the required properties
2. identify the suitable process for modification of the surfaces to meet the industrial challenges

**Text Books:**


1. P. A. Dearnley, Introduction to Surface Engineering, Cambridge University Press, 2017
2. HaraldIbach, Physics of Surfaces and Interfaces, Springer-Verlag, Berlin, 2006, ISBN: 978-3-540-34709-5.
3. Peter J. Blau, Friction Science and Technology - From Concepts To Applications, CRC Press, 2009, ISBN-13: 978-1-4200-5404-0
4. Adamson A W and Gast A P, Physical chemistry of surfaces, 6th Ed., John Willey & Sons 1997.


**Reference Books:**


1. Peter Martin, Introduction to Surface Engineering and Functionally Engineered Materials, Wiley, 2011.
2. J. Paulo Davim, Materials and Surface Engineering: Research and Development, Woodhead Publishing review, 2012.
3. Ramnarayan chattopadhyay, advanced thermally assisted surface engineering processes, Kluwer academic publishers, 2004
4. Sudarshan T S, Surface modification technologies – an engineer's guide; Marcel Dekkar, Newyork, 1989.
5. P.H Morton, Surface Engineering & Heat Treatment, Brooke field, 1991.
6. Varghese C D, Electroplating and other surface treatments – a practical guide, TMH, 1993.


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| HC -MST 309 | Electrochemical Process Technology | 3L: 0T:0P | 3 Credits |
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**Course Objectives:**

1. To understand the basics of electrified interfaces.
2. To learn various electrodes, separators, diaphragms and membranes for electrolytic production of chemicals.
3. To study the electrolytic production of inorganic and organic chemicals.
4. To study electro polymerization and other electro-organic processes.

**UNIT-I (9 hours)**

Basics in Electrochemistry – Electrochemistry of interfaces – Thermodynamics of electric field interface – Semiconductor interfaces – structure of electrified interfaces – types of electrode reactions – over potentials – exchange current density – Butler – Volume equation – current and overpotential at different conditions.

**UNIT-II** **(9 hours)**

Electrodes and separators for the electrolytic production of inorganic chemicals; Preparation and application of graphite, magnetite, lead dioxide coated anodes, Nobel metal coated anodes, Spinal anode, Perovskite anodes, Steel cathode, Coated cathodes, Diaphrams and Separators and Ion – exchange membranes, Monopolar and bipolar membrane cells;

**UNIT-III** **(9 hours)**

Electroytic production of chloro-alkali, sodium hypochlorite, chlorates, bromates and iodates of sodium and potassium; Hydrogen peroxide, manganese dioxide; Basic principles, reaction mechanisms, Effect of operating variables, cell design and operating conditions of industrial cells.

**UNIT-IV** **(9 hours)**

Production of hydrogen by water electrolysis, design of water electrolysers, Electrodialysis and its application in desalination of water and waste recovery; Electrodes and separators for the production of organic chemicals; Basic principles of electro-organic chemistry – Constant current electrolysis, Controlled potential electrolysis, Voltammetry for electro-organic reactions.

**UNIT-V** **(9 hours)**

Electro-polymerizations – Anodic and cathodic polymerization, Effect of reaction parameters on course of the reactions, electrochemical preparation of conducting polymers, Industrial electro-organic processes: Manufacture of adiponitrile and Electro-fluorination of Organic compounds.

**Course Outcomes:**

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

1. Understand the electrified interfaces.
2. Familiarize about various electrodes, separators, diaphragms and membrans for electrolytic production of chemicals.
3. Understand the electrolytic production of inorganic and organic chemicals.
4. Understand the mechanisms of electro polymerization and other electro-organic processes.

**Text Books:**


1. D.Pletcher and F.C.Walsh, Industrial Electrochemistry, Chapman and Hall, London, 1990.
2. A.T.Kuhn, Industrial Electrochemistry, Dekker Inc., New York, 1983.
3. M.M.Baizer, Organic Electrochemistry, Dekker Inc., New York, 1983.
4. M.R.Rifi and F.H.Covitz, Introduction to Organic Electrochemistry, Marcell Dekker Inc., New York, 1994.


**Reference Books:**


1. J.O.M.Bockris and A.K.N.Reddy, Modern Electrochemistry – Vol. I and II, A Plenum Edition, New York, 1970.
2. Allen J Bard and Faulkner, Electrochemical Methods - Fundamentals and Applications, John
3. Willey and Sons, New York, 1983.
4. E.Gileadi, Electrode Kinetics, VCH Publishers, Inc, New York, 1993.


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