1. Conditions for Admission
Candidates for admission to the first year of the four-semester M.E./M.Tech. Degree programme in Engineering shall be required to have passed B.E./B.Tech. degree of Annamalai University or any other authority accepted by the syndicate of this University as equivalent thereto. They shall satisfy the conditions regarding qualifying marks and physical fitness as may be prescribed by the Syndicate of the Annamalai University from time to time. The admission for M.E. Part-Time programme is restricted to those working or residing within a radius of 90 km from Annamalainagar. The application should be sent through their employers.


<table>
<thead>
<tr>
<th>Department</th>
<th>Programme (Full-Time &amp; Part-Time)</th>
<th>Eligible B.E./B.Tech. Programme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Courses of study
The courses of study along with the respective syllabi and the scheme of Examinations for each of the M.E / M. Tech programmes offered by the different Departments of study in the Faculty of Engineering and Technology are given separately.

4. Choice Based Credit System (CBCS)
The curriculum includes three components namely Program Core, Program Electives and Open Electives, Mandatory Learning Courses and Audit Courses in addition to Thesis. Each semester curriculum shall normally have a blend of theory and practical courses.

5. Assignment of Credits for Courses
Each course is normally assigned one credit per hour of lecture / tutorial per week and 0.5 credit for one hour of laboratory or project or industrial training or seminar per week. The total credits for the programme will be 68.

6. Duration of the programme
A student of M.E / M.Tech programme is normally expected to complete in four semesters for full-time / six semesters for part-time but in any case not more than four years for full-time / six years for part-time from the date of admission.
7. Registration for courses

A newly admitted student will automatically be registered for all the courses prescribed for the first semester, without any option. Every other student shall submit a completed registration form indicating the list of courses intended to be credited during the next semester. This registration will be done a week before the last working day of the current semester. Late registration with the approval of the Dean on the recommendation of the Head of the Department along with a late fee will be done up to the last working day. Registration for the Thesis Phase - I and Phase-II shall be done at the appropriate semesters.

8. Electives

8.1 Program Electives

The student has to select two electives in first semester, another two electives in the second semester and one more in the third semester from the list of Program Electives.

8.2 Open Electives

The student has to select two electives in third semester from the list of Open Electives offered by the Department and / or other departments in the Faculty of Engineering and Technology.

8.3 MOOC (SWAYAM) Courses

Further, the student can be permitted to earn credits by studying the Massive Open Online Courses offered through the SWAYAM Portal of UGC with the approval of the Head of the Department concerned. These courses will be considered as equivalent to open elective courses. Thus the credit earned through MOOC courses can be transferred and considered for awarding Degree to the student concerned.

8.4 Value added courses (Inter Faculty Electives)

Of the two open elective courses, a student must study one value added course that is offered by other Faculties in our University either in second or third semester of the M.E programme.

9. Industrial Project

A student may be allowed to take up the one program elective and two open elective courses of third semester (Full Time program) in the first and second semester, to enable him/her to carry out Project Phase-I and Phase-II in an industry during the entire second year of study. The condition is that the student must register those courses in the first semester itself. Such students should meet the teachers offering those elective courses themselves for clarifications. No specific slots will be allotted in the time table for such courses.

10. Assessment

10.1 Theory Courses

The break-up of continuous assessment and examination marks for theory courses is as follows:

<table>
<thead>
<tr>
<th>Assessment Type</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>First assessment (Mid-Semester Test-I)</td>
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</tr>
<tr>
<td>Second assessment (Mid-Semester Test-II)</td>
<td>10</td>
</tr>
<tr>
<td>Third Assessment</td>
<td>5</td>
</tr>
<tr>
<td>End Semester Examination</td>
<td>75</td>
</tr>
</tbody>
</table>
10.2 Practical Courses

The break-up of continuous assessment and examination marks for Practical courses is as follows:

- First assessment (Test-I) : 15 marks
- Second assessment (Test-II) : 15 marks
- Maintenance of record book : 10 marks
- End Semester Examination : 60 marks

10.3 Thesis work

The thesis Phase I will be assessed for 40 marks by a committee consisting of the Head of the Department, the guide and a minimum of two members nominated by the Head of the Department. The Head of the Department will be the chairman. The number of reviews must be a minimum of three per semester. 60 marks are allotted for the thesis work and viva voce examination at the end of the third semester. The same procedure will be adopted for thesis Phase II in the fourth semester.

10.4 Seminar / Industrial Training

The continuous assessment marks for the seminar / industrial training will be 40 and to be assessed by a seminar committee consisting of the Seminar Coordinator and a minimum of two members nominated by the Head of the Department. The continuous assessment marks will be awarded at the end of the seminar session. 60 marks are allotted for the seminar / industrial training and viva voce examination conducted based on the seminar / industrial training report at the end of the semester.

11. Student Counselors (Mentors)

To help the students in planning their course of study and for general advice on the academic programme, the Head of the Department will attach a certain number of students to a member of the faculty who shall function as student counselor (mentor) for those students throughout their period of study. Such student counselors shall advise the students in selecting open elective courses from, give preliminary approval for the courses to be taken by the students during each semester, and obtain the final approval of the Head of the Department monitor their progress in SWAYAM courses / open elective courses.

12. Class Committee

For each of the semesters of M.E / M.Tech programmes, separate class committees will be constituted by the respective Head of the Departments. The composition of the class committees from first to fourth semesters for Full time and first to sixth semesters for Part-time will be as follows:

- Teachers of the individual courses.
- A Thesis coordinator (for Thesis Phase I and II) shall be appointed by the Head of the Department from among the Thesis supervisors.
- A thesis review committee chairman shall be appointed by the Head of the Department
• One Professor or Associate Professor, preferably not teaching the concerned class, appointed as Chairman by the Head of the Department.
• The Head of the Department may opt to be a member or the Chairman.
• All counselors of the class and the Head of the Department (if not already a member) or any staff member nominated by the Head of the Department may opt to be special invitees.

The class committee shall meet three times during the semester. The first meeting will be held within two weeks from the date of class commencement in which the type of assessment like test, assignment etc. for the third assessment and the dates of completion of the assessments will be decided.

The second meeting will be held within a week after the completion of the first assessment to review the performance and for follow-up action.

The third meeting will be held after all the assessments but before the University semester examinations are completed for all the courses, and at least one week before the commencement of the examinations. During this meeting the assessment on a maximum of 25 marks for theory courses / 40 marks for practical courses, for Industrial Training and for Thesis work (Phase-I and Phase-II) will be finalized for every student and tabulated and submitted to the Head of the Department for approval and transmission to the Controller of Examinations.

13. Temporary Break Of Study

A student can take a one-time temporary break of study covering the current semester and / or the next semester with the approval of the Dean on the recommendation of the Head of the Department, not later than seven days after the completion of the mid-semester test. However, the student must complete the entire programme within the maximum period of **four years for Full time / six years for Part time.**

14. Substitute Assessments

A student who has missed, for genuine reasons accepted by the Head of the Department, one or more of the assessments of a course other than the end of semester examination may take a substitute assessment for any one of the missed assessments. The substitute assessment must be completed before the date of the third meeting of the respective class committees.

A student who wishes to have a substitute assessment for a missed assessment must apply to the Head of the Department within a week from the date of the missed assessment.

15. Attendance Requirements

The students with 75% attendance and above are permitted to appear for the University examinations. However, the Vice Chancellor may give a rebate / concession not exceeding 10% in attendance for exceptional cases only on Medical Grounds.

A student who withdraws from or does not meet the minimum attendance requirement in a semester must re-register and repeat the same semester in the subsequent academic years.
16. Passing and declaration of Examination Results

All assessments of all the courses on an absolute marks basis will be considered and passed by the respective results passing boards in accordance with the rules of the University. Thereafter, the controller of examinations shall convert the marks for each course to the corresponding letter grade as follows, compute the grade point average (GPA) and cumulative grade point average (CGPA) and prepare the mark sheets.

- 90 to 100 marks Grade ‘S’
- 80 to 89 marks Grade ‘A’
- 70 to 79 marks Grade ‘B’
- 60 to 69 marks Grade ‘C’
- 55 to 59 marks Grade ‘D’
- 50 to 54 marks Grade ‘E’
- Less than 50 marks Grade ‘RA’
- Withdrawn from the Examination Grade ‘W’

A student who obtains less than 30 / 24 marks out of 75 / 60 in the theory / practical examinations respectively or is absent for the examination will be awarded grade RA.

A student who earns a grade of S, A, B, C, D or E for a course is declared to have successfully completed that course and earned the credits for that course. Such a course cannot be repeated by the student.

A student who obtains letter grade RA / W in the mark sheet must reappear for the examination of the courses.

The following grade points are associated with each letter grade for calculating the grade point average and cumulative grade point average.

S - 10; A - 9; B - 8; C - 7; D - 6; E - 5; RA - 0

Courses with grade RA / W are not considered for calculation of grade point average or cumulative grade point average.

A student can apply for re-totaling of one or more of his examination answer papers within a week from the date of issue of mark sheet to the student on payment of the prescribed fee per paper. The application must be made to the Controller of Examinations with the recommendation of the Head of the Department.

After the results are declared, mark sheets will be issued to the students. The mark sheet will contain the list of courses registered during the semester, the grades scored and the grade point average for the semester.

GPA is the sum of the products of the number of credits of a course with the grade point scored in that course, taken over all the courses for the semester, divided by the sum of the number of credits for all courses taken in that semester.

CGPA is similarly calculated considering all the courses taken from the time of admission.
17. Awarding Degree

After successful completion of the programme, the degree will be awarded with the following classifications based on CGPA.

For First Class with Distinction the student must earn a minimum of 68 credits within four semesters for full-time / six semesters for Part time from the time of admission, pass all the courses in the first attempt and obtain a CGPA of 8.25 or above.

For First Class, the student must earn a minimum of 68 credits within two years and six months for full-time / three years and six months for Part time from the time of admission and obtain a CGPA of 6.75 or above.

For Second class, the student must earn a minimum of 68 credits within four years for full-time / six years for Part time from the time of admission.

18. Ranking of Candidates

The candidates who are eligible to get the M.E /M.Tech degree in First Class with Distinction will be ranked on the basis of CGPA for all the courses of study from I to IV semester for M.E / M.Tech full-time / I to VI semester for M.E / M.Tech part-time.

The candidates passing with First Class and without failing in any subject from the time of admission will be ranked next to those with distinction on the basis of CGPA for all the courses of study from I to IV semester for full-time / I to VI semester for M.E / M.Tech part-time.

19. Transitory Regulations

If a candidate studying under the old regulations M.E. / M.Tech could not attend any of the courses in his/her courses, shall be permitted to attend equal number of courses, under the new regulation and will be examined on those subjects. The choice of courses will be decided by the concerned Head of the department. However he/she will be permitted to submit the thesis as per the old regulations. The results of such candidates will be passed as per old regulations.

The University shall have powers to revise or change or amend the regulations, the scheme of examinations, the courses of study and the syllabi from time to time.

M.E. MICROELECTRONICS AND MEMS

VISION

To nurture higher echelons of technology through participative education, innovative and collaborative research with a view to bring out employable graduates of International standard.

MISSION

- To establish state of art facilities related to diverse dimension in the field of Instrumentation Engineering, Biomedical Engineering and Microelectronics and MEMS.
- To foster higher quality of education with equivocal focus in theory and practical areas of Electronics, Control and Instrumentation Engineering, Biomedical Engineering and Microelectronics and MEMS.
To ensure that the dissemination of knowledge reaches the stakeholders and forge the opening of a fresh flair of human resources.

To create opportunities for advancements in different facets of this discipline and offer avenues to reach the citadels of one’s career.

**PROGRAMME EDUCATIONAL OBJECTIVES**

**PEO1**: To provide a pool of post graduate engineers who are specialists in the modeling and design of basic and advanced semiconductor devices.

**PEO2**: To create a knowledge society in the area of design, fabrication and characterization of micro electro mechanical systems such as microsensors and micro actuators by introducing various simulation tools and micro fabrication technologies.

**PEO3**: To train a group of engineers who would be capable of supporting Indian electronics industry to develop advanced and indigenous microsystems for the modern society.

**PEO4**: To train engineers who would design and develop nano electronic circuits and nano electro mechanical systems for the future world.

**PEO5**: To inculcate students a professional approach to problem solving, using analytical, academic, and communication skills effectively, with special emphasis on working in teams.

**PEO6**: To encourage students to acquire breadth of knowledge, including the multidisciplinary nature of microelectronic engineering as well as the broad social, ethical, safety, and environmental issues within which engineering is practiced.

**PEO7**: To lay the foundation for a strong desire to achieve leadership positions in industry or academia.

**PROGRAMME OUTCOMES**

After the successful completion of the M.E. (Microelectronics and MEMS) degree programme, the students will be able to:

**PO1**: Understand the fundamental scientific principles governing semiconductor electronic devices, modelling of such devices and their incorporation into modern integrated circuits.

**PO2**: Provide the knowledge of semiconductor manufacturing process to utilize thin film processing methods to fabricate and packaging electronic components, communication devices and micromechanical devices. Understand the relevance of a process or device, either proposed or existing, to current manufacturing practices.

**PO3**: Develop in-depth knowledge in existing or emerging areas of the field of Nano electronics such as device engineering, circuit design, lithography, materials and processes, yield, and manufacturing.

**PO4**: Understand the basic concepts of MEMS technology, an interdisciplinary field related to technologies, used to fabricate nano to micro scale devices and system-on-a-chip that embed electrical, mechanical, chemical, and hybrid mechanisms to realize devices and systems for a broad array of applications such as physical sensors, biomedical systems, and complex multifunctional nano-micro systems.
PO5: Introduce students to the techniques of micro and nano-manufacturing, design and multiphysical simulation tools for the analysis of micro and nanostructures and study of their behaviour and the classification of micro and nano sensors and actuators in integrated technology.

PO6: Produce Engineers with the highly specialized knowledge and expertise that they need to design, fabricate, test and package sensors and actuators of micro and nano scale using conventional semiconductor technologies and other emerging technologies.

PO7: Develop process engineer to understand electrical engineering design rules, electronic material properties, and the physics using modern VLSI design tools.

PO8: Produce post graduates who have strong engineering knowledge and technical competence to use techniques, skills and modern engineering tools that allow them to work effectively on the design of VLSI circuits that process Analog, Digital and mixed signals for Communications, Signal Processing and Control Systems.

PO9: Induce an enthusiasm for learning and develop continuous improvement of skills throughout one’s career to adopt and accept changes within the field.

<table>
<thead>
<tr>
<th>Mapping PO with PEO</th>
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<tbody>
<tr>
<td>PO1</td>
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<td>PEO6</td>
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<td>PEO7</td>
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</table>

M.E. (MICROELECTRONICS AND MEMS) FULL-TIME Courses of Study and Scheme of Examination

<table>
<thead>
<tr>
<th>SEMESTER I</th>
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<tbody>
<tr>
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### SEMESTER II

| Sl. No. | Course Code   | Category | Course                          | L | T | P | CA | FE | Total | Credits |
|--------|---------------|----------|---------------------------------|---|--|--|--|----|-----|-------|---------|
| 1      | 19EIMMPC21    | PC       | MEMS Technology                 | 3 |   |   | 25 | 75 | 100   | 3       |
| 2      | 19EIMMPC22    | PC       | MOS Devices and Modelling       | 3 |   |   | 25 | 75 | 100   | 3       |
| 3      | 19EIMMPE23    | PE       | Professional Elective-III       | 3 |   |   | 25 | 75 | 100   | 3       |
| 4      | 19EIMMPE24    | PE       | Professional Elective-IV        | 3 |   |   | 25 | 75 | 100   | 3       |
| 5      | 19EIMMOE25    | PE       | Open Elective-I (Inter Faculty) | 2 |   |   | 25 | 75 | 100   | 3       |
| 6      | 19EIMMCP26    | PE       | MEMS Simulation Laboratory      |   |   | 3  | 40 | 60 | 100   | 2       |
| 7      | 19EIMMTS27    | TS       | Industrial Training / Seminar   | Tr | S |   | 40 | 60 | 100   | 2       |
| 8      | 19EIMMAC28    | AC       | Audit Course-II                 | 2 |   |   | -  | -  | -     | 0       |
|        |               |          | **Total**                       | 20| 5 |   | 495| 700| 19    |         |

### SEMESTER III

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<th>Category</th>
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<td>Open Elective-II (inter faculty)</td>
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### SEMESTER IV

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**Note:** * - Four weeks during the summer vacation at the end of II Semester.

**L:** Lecture, **P:** Practical, **TH:** Thesis, **CA:** Continuous Assessment, **FE:** Final Examination.

<table>
<thead>
<tr>
<th>Category</th>
<th>Code</th>
<th>Description</th>
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<tr>
<td>PC</td>
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<td>M.E Specialization Code</td>
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M.E. (MICROELECTRONICS AND MEMS) PART-TIME
COURSES OF STUDY AND SCHEME OF EXAMINATION (REGULATION-2019)

<table>
<thead>
<tr>
<th>SEMESTER I</th>
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<td></td>
<td></td>
<td></td>
<td>and Modelling</td>
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<td>19PEIMMPC12</td>
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### LIST OF PROFESSIONAL ELECTIVES

1. RF MEMS
2. Semiconductor Power Devices and Modelling
3. Finite Element Analysis for MEMS
4. Polysilicon Technology
5. Microfluidics and Bio MEMS
6. VLSI Design
7. Digital Integrated Circuit Design
8. Advanced VLSI System Design
9. Fundamentals of IC Packaging, Assembly and Test
10. Mixed Signal IC Design
11. Digital System Design with HDL (Verilog)
12. Fundamentals of Nanoelectronics
13. Photovoltaic devices technology
14. Solar cell design and fabrication
15. Introduction to nanomaterials
16. Design and synthesis of nanomaterials
17. Characterization techniques of nanomaterials
18. Nano fabrication Techniques

### LIST OF OPEN ELECTIVES

1. Optoelectronic Materials and Devices
2. MEMS Design and Fabrication

### LIST OF AUDIT COURSES

1. English for Research Paper Writing
2. Disaster Management
3. Value Education
4. Constitution of India
5. Pedagogy Studies
6. Stress Management by Yoga
7. Personality Development through Life Enlightenment Skills

### COURSE OBJECTIVES

- To introduce the basics of semiconductor materials, their electrical properties and quantitative analysis of such materials based on energy band diagrams.
- To acquaint the students with the construction, theory and operation of the P-N junction diode, its characteristics and quantitative analysis of P-N junction diodes.
- To teach the concepts of Bipolar Junction Transistors and quantitative analysis to estimate the performance factors.
- To make the students understand the effect of junction capacitance, their effect on the performance of diodes and BJTs and Breakdown characteristics of these devices.
• To impart knowledge of the operation and characteristics of Photodiodes and phototransistors and qualitative analysis of these devices.


Quantitative analysis of P-N junction Diode: P-N junction under thermal equilibrium – P-N junction under Forward bias – P-N junction under Reverse bias – Behavior under large forward voltage – Temperature dependence of P-N junction characteristics – Break down under reverse bias – Thermal Break down, Zener Break down and Avalanche Break down – Transition capacitance of a P-N junction. Band diagram for a Semiconductor with an applied voltage – P-N junction in thermal equilibrium – Minority carrier densities in a P-N junction under Forward bias – Expression for total current in a P-N junction – Calculation of carrier density and current in a reverse biased junction N-P-N junction behavior in terms of minority carrier stored charge – Calculation of electric field and voltage drop in the bulk.


Junction Transition capacitance and junction Break down voltages: Electric field and potential distribution in P-N junction at thermal equilibrium – transition capacitance and Break down voltages in linearly graded junction and an abrupt junction – $C_T$ in PIN Diode – Break down voltage in transistor.

Quantitative analysis of Photo diodes and Photo transistors: Carrier generation by light in a uniform piece of semiconductor – P-N junction photo diode for light detection – Open circuit photo voltages – Short circuit current in photo diode – Photo diode current under combined action of light and reverse bias – Photo
diode current under combined action of light and forward bias – Photo transistor –
Expression for current in photo transistor – Solar cells using photo diodes.

REFERENCES
4. Donald A. Meamen, Semiconductor Physics and Devices – Basic Principles,

COURSE OUTCOMES
On successful completion of the course, the students will be able to
1. Describe the equations based on energy band diagrams, acceptable
approximations and for intrinsic, p and N type semiconductors
2. Explain the operation of p-n junction diodes quantitatively and qualitatively.
3. Describe the fabrication, device operation of a BJT quantitatively and model
its characteristics from basic principles
4. Understand the effects of junction capacitance and break down voltages on
the performance of P-N junction diodes and BJTs the Classify and describe
the semiconductor devices for special applications
5. To analyze and develop models of optoelectronic devices such as Solar Cells
and LEDs.

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COURSE OBJECTIVES
- To introduce the basic concepts of micro systems and advantages of
  miniaturization.
- To teach the fundamentals of micromachining and micro fabrication techniques.
- To train the students on the design of micro sensors and actuators and
  fabrication flow process.
- To bring both circuits and system views on design together.
- To understand MOS transistor as a switch and its capacitance.

Properties of silicon: Crystal structure – Orientation effects – crystal defects –
Impurities in Silicon – Properties of Silicon and Gallium Arsenide – Starting
materials – Bridgeman techniques for crystal growth – Czochralski technique –
Requirements for proper crystal growth.

Diffusion: Nature of diffusion – Diffusion in a concentration gradient – Diffusion
coefficient – Field aided motion – Impurities for Silicon – Substitutional Diffusers –
Interstitial and Substitutional Diffusers – Diffusion equation –
D-Constant case – Diffusion from a constant source – Diffusion from a limited


**REFERENCES**


**COURSE OUTCOMES**

Upon completing the course, the students will be able to

1. Know the basic concepts of micro systems and advantages of miniaturization.
2. Understand the fundamentals of micromachining and micro fabrication techniques.
3. To be aware about the trends in semiconductor technology, and how it impacts scaling and performance.
4. Expertise the knowledge in design of micro sensors and actuators fabrication.
5. Able to learn Layout, Stick diagrams, Fabrication steps, Static and Switching characteristics of inverters.

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COURSE OBJECTIVES

- To understand the research problem formulation and analyze research related information.

**Research Problem:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Effective literature studies:** Approaches, analysis Plagiarism, Research ethics.

**Effective technical writing:** How to write report, Paper. Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.


**New Developments in IPR:** Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs

REFERENCES


COURSE OUTCOMES

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

- Understand research problem formulation.
- Analyze research related information.
- Follow research ethics.
• Understand that today’s world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.

• Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.

• Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

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**COURSE OBJECTIVES**

• To teach the students the basic concepts of semiconductors with appropriate simulation experiments.

• To make them learn the operation of basic PN junction diode and BJT.

• To make them correlate the results obtained in simulation with the theoretical model.

• To educate the students to develop MATLAB programs for simulating basic electronic devices.

**LIST OF EXPERIMENTS**

• Discrete energy levels possessed by electrons in an isolated atom.

• Temperature dependence of intrinsic carrier concentration in semiconductor.

• Electron and hole concentration in semiconductor doped at different levels.

• Conductivity and resistivity of semiconductor doped at different levels.

• Temperature effects on the probability of occupation of energy levels in a semiconductor.

• Effect of Doping concentration on the contact potential (Vcp) in a P-N junction semiconductor diode.

• Determination of the forward and reverse characteristics of a P-N junction diode parameter like conductivity of P and N region and their Dimension.

• Estimation of BJT performance parameters ($\alpha, \beta, \gamma$) for a given device.

• Analysis of the collector current in P+ – N-P and N+ – P-N transistors for different device parameters.

• Simulation studies on diffusion process and estimation of diffusivity at different temperatures.
COURSE OUTCOMES
At the end of the practical course the students will be able to
1. Understand the concepts they have learnt in the semiconductor devices modeling course.
2. Develop programs to simulate semiconductors, PN junction diode and BJT and verify their operation under different conditions.
3. Develop models for semiconductor devices.
4. Develop MATLAB programs for simulating basic electronic devices.
5. Work as a software developer for semiconductor devices simulation.

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COURSE OBJECTIVES
• To teach the students the practical aspects of oxidation, metal evaporation and spinning in clean room environment.
• To make them correlate the experimental results obtained in the VLSI fabrication processes.
• To make them learn the characterization of packaged electronic devices using advanced semiconductor parametric analyzer.
• To educate the students the wafer level testing of fabricated semiconductor devices and MEMS structures.

LIST OF EXPERIMENTS
1. Determination of I-V characteristics of PV cell at wafer level.
2. Thin film coating of aluminium on Si substrate using Evaporation technique.
3. Thin film coating using spinner at various speeds and standardization.
5. I-V characterization of resistors and LED using Semiconductor parametric analyser.
6. I-V characterization of Semiconductor and Zener diodes with the help of Semiconductor parametric analyser.
7. Determination of I-V characteristics of BJT and MOSFET with the help of Semiconductor parametric analyser.
8. Wafer level device characterization of MOSCAP and MOSFET using Probe station.

COURSE OUTCOMES
On successful completion of the course, the students will be able to
1. Obtain and analyze I-V characteristics of any electronic component using Semiconductor parametric analyser.

2. Observe the I-V characteristics for different packaged MEMS devices using Semiconductor parametric analyser.

3. Perform wafer level testing of any Integrated circuits or MEMS structure using probe station and semiconductor parameter analyser.

4. Conduct thin film metal deposition and thin film coating in clean room environment.

5. Work in any semiconductor industry environment.

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COURSE OBJECTIVES

- To introduce the basic concepts of micro systems and advantages of miniaturization.
- To study the various materials and their properties used for micromachining techniques.
- To teach the fundamentals of micromachining and micro fabrication techniques.
- To impart knowledge of the basic concept of electromechanical effects, thermal effects Micro fluidics and Integrated fluidic systems.
- To teach the fundamentals of pressure sensors and accelerometer sensors through design and modeling.
- To give exposure to different MEMS devices.


and sputtering - CVD of metals - adhesion layer for metals - electro deposition (E plating) - Electrodeposition mechanism: - DC electroplating-pulsed electroplating-Agitation for electroplating-black metal film-electro less plating.

**Bonding Processes:** Anodic Bonding-Anodic bonding using deposited glass-silicon fusion bonding-other bonding and techniques-compound processes using bonding.

**Sacrificial Processes and Other Techniques:** Sticking problem during wet releasing-prevention of sticking-phase change release methods-geometry-examples of sacrificial processes - Sacrificial LIGA process:

**Advanced MEMS for Sensing and Actuation:** Electromechanical effects: Piezoresistance - Piezoelectricity - Shape memory alloy-Thermal effects: Temperature coefficient of resistance - Thermo-electricity – Thermocouples – Micro fluidics: - Squeeze film damping - Surface tension and bubbles -Devices: pumps, valves, mixers -Integrated fluidic systems: BioMEMS.


**REFERENCES**


**COURSE OUTCOMES**

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

1. Gain thorough knowledge of materials used for micromachining techniques
2. Understand the process of Bulk Micro Machining techniques.
3. Acquire the knowledge of Electromechanical effects, Thermal effects, Micro fluidics, Devices such as pumps, valves, mixers, Integrated fluidic systems and BioMEMS.
4. Analyze and develop models for different types of Pressure Sensors and accelerometers.
5. Acquire expertise in the design of sensors for any practical applications.

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**COURSE OBJECTIVES**

To introduce the basic concepts of MOS structure under different modes of operation and characteristics

- To educate on solving the problem based on MOS structure
- To teach the fundamentals of MOSFET operation under various SPICE level models
- To impart knowledge about short and long channel effects
- To provide an overview on the design of SOI MOSFETs and High Speed Devices

**MOS Structure:** Ideal MOS structure and different modes of operation – Ideal MOS structure under thermal equilibrium, accumulation mode, depletion mode and inversion mode – Small signal capacitance of MOS structure in depletion – Threshold voltage of ideal MOS structure – C-V characteristics of MOS capacitor – Effects of non-idealities on MOS characteristics – effect of work function, charges on oxide like fixed oxide charge, mobile ionic charge, oxide trapped charge and interface trap density – Threshold voltage including non-idealities.

**MOSFET Operation:** Qualitative operation of square law model and for static characteristics – (SPICE level 1) for MOSFET characteristics – Bulk charge model (SPICE – level 2 model) – SPICE level 3 model – Body effect or substrate bias effect – Subthreshold conduction in MOSFET – Small signal model for MOSFETs.

**Short Channel Effects:** Short channels effects on threshold voltage – Channel length modulation – Velocity saturation – Breakdown voltage – Scaling and types of scaling – Short channel devices modeling.

**SOLAR CELLOPTOSI MOSFETS:** Advantages of SOI MOSFETs – SOI wafer fabrication techniques – Partially depleted SOI MOSFET – Threshold voltage of a partially depleted SOI MOSFETs – Kink effect – Fully depleted SOI MOSFET – Threshold voltage of fully depleted SOI MOSFET.

**High Speed Devices:** Metal Semiconductor contacts – metal conducts on N type semiconductor and P type semiconductor – Surface states and their effects – Schottky barrier function. **MESFETs** – Structure of GaAs MESFETs – Pinch off voltage and threshold voltage – MESFET modelling.

**REFERENCES**


**COURSE OUTCOMES**

At the end of the course the students will be able to
1. Know the basic concepts of MOS structure under different modes of operation and characteristics
2. Understand the fundamentals on solving the problem based on MOS structure
3. Gain the expertise on fundamentals of MOSFET Operation under various SPICE level models and problem solving
4. Understand the design concepts about short and long channel effects
5. Acquire knowledge on the SOI MOSFETS and High Speed Devices

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**COURSE OBJECTIVES**

- To teach the students the existing industrial standard software tools available for MEMS design.
- To make them learn the simulation Pressure Sensors and piezo resistors, RF MEMS switches.
- To make them correlate the results obtained in simulation with the theoretical model.
- To educate the students to design MEMS sensors and actuators using IntelliSuite, CoventorWare and COMSOL.

**LIST OF EXPERIMENTS**

1. Study of IntelliSuite Software for the design and fabrication process of MEMS devices.
3. Construction and Simulation of RF Switch.
7. Studies on effect of Air Gap on Pull – in voltage of fixed beam employed in RF Switch.
8. Design and Construction of different types of Accelerometer and determination of its natural frequency
   a) Design and Analysis of Piezoresistive Accelerometer using CoventorWare software.
b) Design and Analysis of Comb drive type Capacitive Accelerometer using IntelliSuite software.

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

1. Know the basic concepts of MEMS structures under different modes of operation and characteristics.
2. Understand the fundamentals on solving the problem based on MEMS structure.
3. Gain the expertise on fundamentals of MEMS design and operation.
4. Understand the design concepts of MEMS sensors and actuator for practical applications.
5. Work in any MEMS design industry.

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COURSE OBJECTIVES

- To train the students in the field work related to Microelectronics and MEMS to have a practical knowledge in carrying out Microelectronics and MEMS field related works.

- To train and develop skills in solving problems during execution of certain works related to Microelectronics and MEMS.

The students individually undergo a training program in reputed concerns in the field of Microelectronics and MEMS during the summer vacation (at the end of second semester for full-time/fourth semester for part-time) for a minimum stipulated period of four weeks. At the end of the training, the student has to submit a detailed report on the training they had, within ten days from the commencement of the third semester for Full-time/fifth semester for part-time. The students will be evaluated by a team of staff members nominated by head of the department through a viva-voce examination.

COURSE OUTCOMES

1. The students can face the challenges in the practice with confidence.
2. The student will be benefited by the training with managing the situation arises during the execution of works related to Microelectronics and MEMS.
COURSE OBJECTIVES

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
- To train the students in preparing project reports and to face reviews and viva voce examination.

COURSE OUTCOMES

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

1. Take up any challenging practical problems and find solution.

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COURSE OBJECTIVES

- To impart knowledge on RF Circuits and associated parameters.
- To educate on RF MEMS Circuit Elements and modelling.
- To provide an overview on reconfigurable circuit and circuit elements.
- To introduce the concepts and working of reconfigurable antennas
- To give an overview of the RF MEMS based phase shifter and oscillator.

**Motivation for RF MEMS:** Advantages of developing MEMS based RF passive components and RF circuits – Physical aspects of RF design – Skin effect – Transmission lines on thin substrate – self resonance frequency – Quality factor – Packaging – Practical aspects of RF circuit design – DC biasing – Impedance mismatch effects in RF MEMS.

**RF MEMS enabled circuit elements:** RF/Microwave substrate properties – micromechanical enhanced elements – Capacitors – Inductors – Varactors – RF MEMS switches – Shunt MEM switch – Low voltage hinged MEM switch – Push pull series switch – folded beam spring suspension series switch.

**RF MEMS based Circuit Elements:** Resonators – Transmission line planar resonator – Cavity resonators – Micromechanical resonators – Film acoustic wave resonator MEMS modeling – MEMS mechanical modeling – MEMS electromagnetic modeling.

**Reconfigurable circuit elements:** The resonant MEMS switch – Capacitors – Inductors – Tunable CPW resonator – MEMS micro switch arrays. **Reconfigurable circuit:** Double stub tuner – n\textsuperscript{th} stub tuner – Filters – Resonator tuning system – Massively parallel switchable RF front ends – True time delay digital phase shifters. **Reconfigurable antenna:** Tunable dipole antenna – Tunable micro strip patch – Array antenna.

**Phase shifter:** X band and K\textsubscript{a} band millimeter wave micromachined tunable filter – A high 8 MHz MEMS resonator filter. **RF MEMS oscillator:** 14 MHz MEMS oscillator – Case study and a K\textsubscript{a} band micromachined cavity oscillator.

**REFERENCES**


**COURSE OUTCOMES**

Upon completing the course, the student should

1. Understand the basic concepts of RF MEMS.
2. Acquire the working concepts of RF MEMS Circuit Elements.
3. Understand the concepts and structure of RF MEMS Circuits, reconfigurable RF MEMS circuits and elements and their modelling.
4. Acquire the working knowledge of RF MEMS based reconfigurable antenna.
5. Understand the concepts and working of RF MEMS based phase shifter and oscillators.

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19EIMMPEXX SEMICONDUCTOR POWER DEVICES AND MODELLING

COURSE OBJECTIVES
- To introduce the basics of semiconductor devices, used in the power electronics.
- To acquaint the students with the construction, theory and operation of the power diodes, its characteristics and quantitative analysis.
- To teach the concepts of power JFET and quantitative analysis to estimate the performance factors.
- To make the students understand the structure, function and application of power MOSFET, in power electronics.
- To impart knowledge of the operation and characteristics of power field control devices and IGBT


Power JFETs: Basic structure and operation – Basic device characteristics – Field independent and dependent mobility analysis – Space charge limited current flow – Triode – Pentode transition – Effect of the drift region – Punch through structure – Frequency response.


REFERENCES

COURSE OUTCOMES
On successful completion of the course, the students will be able to
1. Understand the function and application of power diodes.
2. Explain the operation of Power JFET quantitatively and qualitatively.
3. Describe the device operation of power field controlled diodes quantitatively and model its characteristics from basic principles.
4. Understand the structure and characteristics operation of the power MOSFET.
5. Understand the basic structure and modelling of IGBT.

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COURSE OBJECTIVES
- To equip the students with the Finite Element Analysis fundamentals.
- To model and analyze 1D and 2D finite elements for structural elements like beam, frame and plane elements.
- To introduce basic aspects of finite element technology, including domain discretization, Polynomial interpolation, application of boundary conditions, assembly of global arrays, and solution of the resulting algebraic systems.
- To help the students use FEA method and commercial software package to solve problems in heat transfer, mechanics of materials and machine design.
- To familiarize students with professional – level finite element software like ANSYS.

Introduction: Basic Principles of Finite Element Method – Modern Concepts in Simulation and Modelling (Behavioral Modelling, Modelling Levels such as device and system – level) – Some basic but important mathematical and physical concepts in FEA – Concepts such as elements and nodes, Discretization and other Approximations.

1D FEA and 2D FEA: One – Dimensional FEs (e.g., beams, bars, cables and springs). Stiffness and load vector formulations and boundary conditions. Two
Dimensional Finite Elements. Discussion includes plane elements (plane – stress and plane – strain), and plate elements.

**Thermal Analysis:** Basic Equations. FEs for thermal analysis. Thermal transients. Discussion on Modelling, Numerical Errors and Accuracy. Discussion includes tests for elements, sources and detection of numerical errors, convergence study, and adaptive techniques. **Basic Electromagnetics:** Basic Electromagnetic Equations, FEs for field equations, transients.

**Dynamic Analysis:** Free vibration and dynamic problems. Include response spectra analysis. **Computational Fluid Dynamics (CFD):** Basic Navier – Stokes Equations. FEs for fluids elements of CFD – Microfluidics. Discussion on stability analysis and nonlinear analysis. Solution algorithms and convergence.


**REFERENCES**


**COURSE OUTCOMES**

Upon completing the course, the student should have

1. The ability to identify mathematical model for solution of common engineering problems and formulate finite elements model to obtain the solutions.
2. Familiarity to use professional – level finite element software to solve engineering problems in solid mechanics, fluid mechanics and heat transfer.
3. The capability to derive element matrix equation by different methods based on basic laws in mechanics and integration by parts.
4. Learnt the formulation of one – dimensional, two – dimensional, and three dimensional elements used in MEMS sensors and actuators.
5. Exposure to conduct FEA using commercial FEM software.
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**COURSE OBJECTIVES**

- To introduce on polysilicon deposition and various processes.
- To explain electrical properties, Carrier Transport, Effective mobility and different passivation techniques of polysilicon.
- To teach the vital applications of Polysilicon.
- To make the students understand modelling of PSOI MOSFETs and threshold voltage model for various modes of PSOI MOSFETs.
- To educate the concepts of Polysilicon for MEMS applications and motivate the students to design different devices.


**Polysilicon applications**: As resistor – Zero temperature coefficient resistor using polysilicon – High value resistors – Polysilicon links – Polysilicon diodes – Polysilicon solar cells – Self aligned gate technology using polysilicon.

**PSOI MOSFETs**: finite elementComparison of single crystal silicon MOSFETs and polysilicon MOSFETs – Application of polysilicon TFT for AMLCDs and SRAM – Inversion mode PSOI MOSFETs – Modelling of PSOI MOSFETs – Threshold voltage model of inversion mode PSOI MOSFETs – Passivation and its influence on the transistor parameters – Effect of doping on threshold voltage in PSOI MOSFETs – Accumulation mode PSOI MOSFETs – Advantage of accumulation mode PSOI MOSFETs – Threshold voltage model for accumulation mode PSOI MOSFETs.

**Polysilicon for MEMS applications**: – Polysilicon mechanical properties – Polysilicon cantilever structures – MEMS switches using polysilicon-Polysilicon piezo resistor for MEMS pressure sensor application – Floating gate transistor for gas sensing applications – MEMS integration using polysilicon TFTs with polysilicon structures.
REFERENCES

COURSE OUTCOMES

Upon completing the course, the student should have

1. Understood the concept of polysilicon deposition and various processes.
2. Acquired the expertise on electrical properties, Carrier Transport, Effective mobility and Different passivation techniques of polysilicon.
3. Understood the vital applications of Polysilicon.
4. Understood the modelling of PSOI MOSFETs and threshold voltage model for various modes of PSOI MOSFETs.
5. Acquired the complete knowledge of the design of Polysilicon for MEMS applications.

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<td>• To impart knowledge on microfluidics and fluidic sensors.</td>
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<td>• To educate on the design of micropumps.</td>
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<td>• To provide an overview on chemical sensors and transducers.</td>
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<td>• To introduce the concept of work function based sensors</td>
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<td>• To give an overview of the sensors application in the field of biology.</td>
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**Fluidics Fundamentals:** Basic fluid properties and equations – Types of flow – Bubbles and particles in microstructures – Capillary forces – Fluidic resistance – Fluidic inductance – Bulk micromachined channels – Surface micromachined channels.

**Micropumps:** Membrane pumps – Diffuser pumps – Rotary pumps – Electrohydro dynamic (EHD) pumps – Injection type and non-injection type EHD – Microfluidic system issues – Interconnect packing and system integration – Design for disposable or reuse.

**Passive chemical sensors:** Chemiresistors – Chemicapacitors – Chemomechanical sensors – Calorimetric sensors – Metal Oxide gas sensors.

**Work function based Sensors:** ADFET gas sensors – Platiniude based hydrogen sensors – Ion sensitive FETS (ISFETS and CHEMFETS).

**Electrochemical Transducers:** Ionic Capacitance – Charge transfer – Resistive mechanisms – Spreading resistance and Warburg impedance – Basic electrode circuit model – Electrochemical sensing using micro electrodes.


**REFERENCES**


**COURSE OUTCOMES**

Upon completing the course, the student should

1. Understand the basic properties of microfluids.
2. Acquire the working concepts of fluidic sensors.
3. Understand the concepts and structure of micrompums.
4. Acquire the working knowledge of Passive chemical sensors, Work function based Sensors, Electrochemical Transducers.
5. Understand the application of sensors for various biological applications.

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COURSE OBJECTIVES

- To introduce the basic theories and techniques of digital VLSI design in CMOS technology.
- To describe the general steps required for processing of CMOS integrated circuits.
- To understand the concept behind ASIC (Application Specific Integrated Circuits) design and the different implementation approaches used in industry.
- To bring both Circuits and System views on design together.
- To analyze performance issues and the inherent trade-offs involved in system design.


**Tests:** Design for Testability – Test Program Development – Prototype Evaluation

**ASIC Construction:** Interconnects and Routing, Floorplanning – Placement – Physical Design Flow – Information Formats.

REFERENCES

COURSE OUTCOMES

Upon completing the course,

1. Student will be able to design digital systems using CMOS circuits.
2. Be able to use mathematical methods and circuit analysis models in analysis of CMOS digital electronics circuits.
3. Student will be able to learn Layout, Stick diagrams, Fabrication steps.
4. It offers a profound understanding of the design of complex digital VLSI circuits, computer aided simulation and synthesis tool for hardware design.
5. Student will be able to understand the concept behind ASIC (Application Specific Integrated Circuits) design and the different implementation approaches used in industry.

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COURSE OBJECTIVES

- To introduce the fundamentals of digital integrated circuits and expose them to examples of applications.
- To give the ability to analyze, design, and optimize digital circuits with respect to different quality metrics: cost, speed, power dissipation, and reliability.
- To give the basic background to go through a complete digital design cycle: analysis, design, simulation, layout and verification.
- To analyze and design of static sequential circuits and understand basic clocking issues.
- To know the basics of semiconductor memories.


**Design of I/Os and Clock Generation:** I/O Structures – PLL, clock generation and clock buffering – Design of Memory: Memory Core – Memory Peripheral Circuits – Memory Faults and Test Patterns.

**Digital System Design using Hardware Description Language:** Introduction to HDL, Modeling and Designing with VHDL – VHDL Description of Combinational Networks – VHDL Description of Sequential Networks – VHDL Model for Memories.

**REFERENCES**


**COURSE OUTCOMES**

Upon completing the course, the students will be able to

1. Understand the impact of technology scaling.
2. Understand the basic operation of MOS transistors, current equations, and parasitic and to understand the concepts of propagation delay, power consumption of CMOS ICs.
3. Know how to analyze and design complex logic gates in standard CMOS technology and compute their delay and power consumption.
4. Be able to analyze and design of static sequential circuits and understand basic clocking issues.
5. Know the basics of semiconductor memories.

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**COURSE OBJECTIVES**

- To introduce the concepts and techniques of modern integrated circuit design and testing (CMOS VLSI).
- To train the students on the design project involved with data path operators, data registers, serial/parallel conversion, clocking/timing details and feedback.
- To complete a significant VLSI design project having a set of objective criteria and design constraints.
- To develop tests, and the use of design for testability techniques during the VLSI system design and implementation process.
- To use automated layout tools to produce geometric descriptions of complex integrated circuit designs with VLSI chip.


REFERENCES

COURSE OUTCOMES
Upon completing the course,
1. Student will be able to learn and participate in the process of modern VLSI design and verification.
2. Student will be able to develop an understanding for the advanced design concepts in modern VLSI technologies.
3. Student will be able to design and layout a complex chip containing entities such as a register arrays, shifters, multipliers, an arithmetic logic unit (ALU), and other large scale devices.
4. Student will be able to Apply techniques used to test and debug IC designs
5. Be able to complete a VLSI design project having a set of objective criteria and design constraints.

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COURSE OBJECTIVES

- To know the importance on Integrated Circuit Packaging.
- To impart the knowledge on various manufacturing process technologies.
- To understand the design considerations on electrical, thermal and mechanical parameters.
- To test and analyse the performance characteristics of Integrated Circuit Packages.
- To study and understand various emerging technologies in the field of Integrated Circuit Packaging.


Emerging Technologies: Ball Grid Array, Chip – scale package (CSP) – Flip Chip, Direct Chip Attach (DCA) and Wafer Scale package (WSP) – 3D Packaging – Known Good Die.

 REFERENCES

COURSE OUTCOMES

Upon completing the course, the student should have
1. Understood the importance and issues of Integrated Circuit Packaging.
2. Acquired the expertise in the manufacturing of various Integrated Circuit Packages.
3. Understood the design considerations on various physical parameters.
4. The ability to test and analyse the performance characteristics of Integrated Circuit Packages.
5. Acquired the knowledge of various emerging Integrated Circuit Package technologies.

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**COURSE OBJECTIVES**

- Exposure to analog and digital circuit design techniques in integrated context.
- Learn to design mixed – signal building blocks including comparators and data converters.
- To Gain experience with system level design flow: bottom – up and top – down design methodologies
- To gain mixed – signal design experience in Cadence CAD tools, including both custom and automated design
  - Analog, Digital and Mixed – Mode simulation
  - Digital synthesis and Place & Route
  - Layout, DRC, LVS, Post – layout verifications

**Submicron CMOS:** Overview and Models – CMOS Process Flow – Capacitors and Resistors – Using a MOSFET as a Capacitor – Using a Native or Natural MOSFET Capacitor – The Floating MOS Capacitor Metal Capacitors – Resistors – SPICE MOSFET Modeling – Model Selection – Model Parameters


**Design of data converters:** Nyquist rate A/D converters (Flash, interpolating, folding flash, SAR and pipelined architectures), Nyquist rate D/A converters (voltage, current and charge mode converters) hybrid and segmented converters –
Oversampled A/D and D/A converters – Delta – Sigma data converters – Design of PLLs, DLLs and frequency synthesizers.

REFERENCES

COURSE OUTCOMES
Upon completing the course, the students will be able to
1. Appreciate capabilities and limitations of advanced microelectronic (or IC) technologies.
2. Understand and use advanced circuit models of IC components
3. Analyse analogue and digital microelectronic circuits
4. Design analogue, digital and mixed microelectronic circuits
5. Critically read and present papers from technical journals, and keep up-to-date with future technological development in the field.

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COURSE OBJECTIVES
- To impart knowledge on Hardware description language.
- To give an overview of Switch and Gate Level Modeling.
- To educate the importance of the timing and delay in VHDL.
- To create the knowledge in VHDL simulators.
- To impart knowledge on the synthesis using VHDL.


Logic Modelling: Switch and Gate Level Modeling – Gate types – Gate level multiplexer – gate level 4 bit full adder – gate delays – Rise, fall and turn off delays – min/typ/max delay values – Data flow modeling: Continuous assignments – regular


REFERENCES

COURSE OUTCOMES
Upon completing the course, the student should
1. Understand the basic operation of Verilog simulators.
2. Acquire knowledge of different modelling methods like Switch, Gate Level and Behavior Modeling
3. Understand the concepts of introducing timing and delay in VHDL programming.
4. Acquire the working knowledge in VHDL simulation.
5. Understand the synthesis process in VHDL.

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COURSE OBJECTIVES
- To introduce the idea of quantum mechanics which is totally different from classical mechanics
- To impart knowledge of the structure of carbon nanotubes and its properties
- To make the students to understand principles, properties and applications of carbon nanotubes devices
- To study about generation of CNTFETs and its fabrication techniques
- To familiarize the students to model the nano electronic devices


**Carbon Nanotube (CNT):** The Structure of Carbon Nanotube s- Graphene band structure, properties. Synthesis of Carbon Nanotubes – electronic, vibrational, mechanical and optical properties of CNT- Applications of CNT. Fabrication of Fullerene (C60). Functionalization of Carbon Nanotubes: covalent functionalization of CNTs-non covalent functionalization of CNTs- modification of CNTs via mechnochemical reactions - electrochemical deposition, electroless deposition; plasma activation of CNTs.


**CNT Transistors:** Generation of CNTFETs – Bottom gate transistor- Top gate transistor – Cylindrical gate transistor, Fabrication Techniques : Di-Electrophoresis method - Solution deposition – Imprint Techniques.

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**REFERENCES**

2. Lessons from Nanoelectronics. A New Perspective on Transport-Supriyo Datta, Purdue University, USA, 2012.
On successful completion of the course, the students will be able to

1. Understand the basics of quantum mechanics with reference to electron.
2. Gain indepth knowledge of the structure of carbon nanotubes and its properties
3. Understand principles, properties and applications of carbon nanotubes devices for Nanoelectronics.
4. Acquire the knowledge of CNTFETs and its fabrication techniques
5. Model and fabricate a CNT based nanoelectronic device using various fabrication techniques with the thorough knowledge of material and device properties.

COURSE OBJECTIVES

- To introduce the basics of semiconductor materials, their electrical properties and optical properties
- To acquaint the students with the fundamentals of silicon solar cells, theory and operation of silicon solar cells, its fabrication and characterization analysis of silicon solar cells
- To teach the concepts of Dye sensitized solar cells with its Pros and Cons
- To make the students understand the concept of conjugated polymer solar cells for various structures
- To impart knowledge of the operation and characteristics of quantum dot solar cells and qualitative analysis of these devices.

**Fundamentals of Solar cells:** Basic of Semiconductor Physics- the p-n junction, charge carriers in semiconductors, optical properties of semiconductors, Hetero- junctions, Solar energy fundamentals—nature of solar energy, conversion of solar energy, photochemical conversion of solar energy, photovoltaic conversion, photophysics of semiconductors and semiconductor particles, photocatalysis.

**Silicon solar cells:** Device physics of silicon solar cells- Semiconductor device equations, The p-n junction model of Shockley, Real diode characteristics, Crystalline silicon solar cells- Silicon cell development, Substrate production, cell processing, cell cost, Opportunities for improvement, amorphous silicon solar cells, Amorphous silicon-based materials, Manufacturing costs, Environmental issues, Challenges for the future.

**Dye sensitized solar cell:** Photoelectrochemical solar cell, semiconductor electrolyte interface, Basic principle and working of Graetzel Cell i.e., dye sensitized solar cells (DSSCs), Derivation of the Lifetime in DSSCs, theory of EIS, IMPS-IMVS for DSSCs, factors affecting on efficiency of DSSCs, present DSSCs research and developments, limitations of DSSCs.

**Polymer based Solar Cells:** Introduction to conducting polymers, basic principle of HOMO & LUMO, bulk heterojunction polymer: solar cell Basic working principles, device architectures, single layer, Bilayer, Bulk heterojunction, diffuse
bilayer heterojunction, tandem solar cell, efficiency relationship in organic bulk heterojunction solar cells.

**Quantum Dot Sensitized Solar Cells:** Quantisation effects in semiconductor nanostructures, optical spectroscopy of quantum wells, super lattices and quantum dots, Basic principle and working of quantum dot sensitized solar cells, effect of device architecture, theory of electron and light dynamic in QDSSCs, study of EIS, IMPS-IMVS in QDSSCs.

**REFERENCES**

- Physics of solar cells from principles to new concepts: Peter Wurfel
- Photoelectrochemical Solar Cells: Suresh Chandra
- Solar energy conversion: A. E. Dixon and J. D. Leslie
- Solar cells: Martin A. Green
- Solid State electronic Devices: B.G. Streetman
- Photoelectrochemical solar cell: Suresh Chandra
- Dye sensitized solar cell: Michael Graetzel (Review Articles)
- Quantum Dot Solar Cells. Semiconductor Nanocrystals as Light Harvesters: P. V. Kamat (Review Articles)
- Clean electricity for photovoltaics: Mary D. Archer & Robert Hill

**COURSE OUTCOMES**

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

1. Understand the basics of semiconductor materials, their electrical properties and optical properties
2. Gain the knowledge of the fundamentals of silicon solar cells, theory and operation of silicon solar cells, its fabrication and characterization analysis of silicon solar cells
3. Understand the basic concepts of Dye sensitized solar cells with its Pros and Cons
4. Understand the concept of conjugated polymer solar cells for various structures
5. Gain the knowledge of the operation and characteristics of quantum dot solar cells and qualitative analysis of these devices.

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COURSE OBJECTIVES

- To learn the fundamentals of solar energy conversion systems, available solar energy and the local and national needs, photovoltaic and photothermal engineering applications, emerging technologies.

- To understand the interdisciplinary approach for designing stand-alone PV systems, predicting performance with different systems, implementing design with cost analysis, gain system engineering expertise related to photovoltaic energy conversion: generation, storage, and grid connection processes for residential and industrial applications.

- Be able to advance the current technology of the solar energy systems for making the process economical, environmentally safe and sustainable. Be able to serve industries or academia involved in sustainable energy engineering.

**Concepts of Solar energy:** the sun, Available solar energy from the sun, insolation vs. world energy demand, Blackbody radiation, Planck’s Radiation Law, Wien’s displacement Law, Stefan Boltzmann Equation, spectral distribution of extraterrestrial and terrestrial radiations, solar constant, properties of solar radiation Sun-Earth Geometry: Motion of the earth relative to the sun, Apparent motion of the sun relative to a fixed observer on the earth, Air Mass, estimation of available solar radiation on earth, absorption of solar radiation by earth’s atmosphere, direct, diffused and albedo components of sunlight, solar radiation table, global radiation data. Mean annual irradiance on horizontal surface across the world, Effects of latitude, declination, slope, surface azimuth angle, hour angle, and the angle of incidence. Radiation on an inclined surface: direct, reflected, and diffused radiations, radiation on inclined surfaces, calculation of angles of incidence, direction of beam radiation, angles for tracking surfaces, ratio of beam radiation on tilted surface to that of horizontal surface.

**Photovoltaic technology:** Introduction to PV, conversion of solar radiation to electrical energy, PV sizing for meeting the world’s energy need, how much land area is needed, advantages and disadvantages of PV systems. Reliability and sizing of the PV/PT systems, uncertainty and risk factors in PV/PT design, Cost analysis, Terawatt challenge, Energy payback, different options of PV modules, thin film solar cells. Light absorption, Direct-bandgap and indirect bandgap semiconductors, light absorption coefficient, Reflection and reflection losses, Absorption as a function of photon energy, Carrier transport.

**Performance parameters of PV cells:** Fundamental principles of solar cell operation, Solar cell device physics, Basic structure of solar cells, Quasi Fermi energy levels, Law of junctions, Carrier generation rate, Recombination rate, Dark current, Light generated current, Current-voltage (I-V) relationship. Solar cell output parameter, Fill factor, solar cell efficiency, Short circuit current, Open circuit voltage, Maximum power point operation, Effect of finite width of the solar cell, Solar cell equivalent circuit, Effect of bandgap, maximum thermodynamic efficiency. Practical efficiency limit, Losses in short circuit current, open circuit...
voltage, efficiency, Temperature effects, Fill factor losses, I-V characteristic measurement, Efficiency measurement, Parasitic resistances, Effects of series and shunt resistances


**Performance evaluation of solar modules:** Measurements and characterization of solar cells and PV modules, V – I characteristics, spectral response measurements, measurements and characterization of thin film solar cells Domestic, industrial and commercial applications, Lifetime of the PV modules, Degradation caused by UV radiation, Moisture penetration, Corrosion, Dust deposition/soiling losses, Reflection losses, Thermal effects, Delamination of the module, prevention of energy yield losses.

**REFERENCES**
1. Solar Cells: Operating Principles, Technology and System Applications, Martin Green published by the University of New South Wales, 1980 (Required) available at the BU Barnes and Noble book store
4. Thin film Solar Cells, Jeff Poortmans and Vladimir Arkhipov (Ed) John Wiley and Sons Ltd. 2006
8. www.pveducation.org

**COURSE OUTCOMES**
As an outcome of completing this course, the students will:

1. Gain an understanding of the available solar energy and the current solar energy conversion and utilization processes,
2. Have a working knowledge of semiconductor physics, optical systems, load matching, and storage and grid connections related to photovoltaic engineering,

3. Be able to comprehend the challenges in sustainable energy processes, perform cost analysis, design photovoltaic systems for different applications meeting residential and industrial needs, predict and test performance, and

4. Understand the manufacturing processes involved, environmental challenges that need to be solved, economic aspects, and future potentials of solar energy utilization

5. Evaluate the performance of a PV solar module using various measurement techniques

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<td>• To impart knowledge of nanomaterials, its properties and structure.</td>
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<td>• To give an overview of fabrication techniques involved in nano fabrication process.</td>
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<td>• To understand the function of nanoparticles.</td>
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<td>• To study the fabrication of nanostructures.</td>
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**Introduction:** Feynmann’s vision on nanoscience & technology, bulk vs nanomaterials, natural and synthetic nanomaterials. Quantum confinement in nanostructures- size dependent physical phenomena in semiconductor and metal nanoparticles. Classification of nanostructures, 0D, 1D and 2D nanostructures. Visualization of nanostructures and techniques related.

**Surface Energy:** Surface energy and surface stress-origin and estimation of surface energy. Surface Energy minimization:- Sintering Ostwald ripening and agglomeration. Energy minimization by Isotropic and anisotropic surfaces. Surface energy and surface curvature, Surface energy stabilization, electrostatic stabilization, steric stabilization, electro-steric stabilization.

**Size and shape dependence of nanoparticles:** Size effect on the morphology of free or supported nanoparticles, Equilibrium shape of macroscopic crystal. Wulff theorem, equilibrium shape of nanometric crystals. Wulff-Kaichew theorem, equilibrium shape of supported nanoparticles. Kinetics of phase transformations, Homogeneous & Heterogeneous nucleation. Controlling nucleation, growth and aggregation in nanoparticle growth, and crystalline Phase Transitions in Nanocrystals.
Fabrication of nanostructures: Bottom-up approaches for nanostructure fabrication:- Self assembly. Top down approaches for nanostructure fabrication- Lithography- Photolithography- Laser lithography and SPM based lithography (AFM & STM) and nanomanipulation.

REFERENCES

COURSE OUTCOMES
Upon completing the course, the student will be able to
1. Understand the basic properties of nano materials and their importance in Nanoelectronics.
2. Gain the knowledge of nanomaterials structure.
3. Acquire the knowledge of the fabrication techniques involved in nano fabrication process.
4. Understand the function of nanoparticles.
5. Provide expertise in the fabrication of nanostructures.

Mapping of COs with POs

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19EIMMPExX DESIGN AND SYNTHESIS OF NANOMATERIALS L T P C
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COURSE OBJECTIVES
- To introduce the basic theories and techniques of various synthesis methods of nano materials
- To study the various lithographic techniques and its applications in nanofabrication
- To understand the biological methods of synthesis.
- To know the various lithographic techniques used in nanomaterial synthesis.


Chemical Methods: Nanoparticles through homogeneous & heterogenous nucleation in solution:- Co-precipitation method, Hydrothermal/ Solvothermal synthesis, Template based synthesis, Electrochemical synthesis, Sonochemical

**Biological Methods of Synthesis:** Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Viruses as components for the formation of nanostructured materials; Role of plants in nanoparticle synthesis.


**REFERENCES**


**COURSE OUTCOMES**

Upon completing the course the students will be able to,

1. Synthesize of various nano materials for several MEMS applications.
2. Characterize and analyse the synthesized nano materials
3. Understand the biological methods of synthesis
4. Gain the knowledge of various lithographic techniques
5. Use the imprint technology for nanomaterial synthesis.

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**COURSE OBJECTIVES**

- To study the various spectroscopic characterization techniques to investigate the properties of nano materials
- To impart the knowledge to the students regarding various microscopic techniques available
• To teach the characterization techniques to analyse thermal characteristics of nano materials
• To understand the mechanical properties of nanomaterials using different characterization methods
• To study the magnetic and electrochemical properties of nanomaterials using various suitable techniques


**Magnetic and Electrochemical Techniques:** Magnetic Vibrating Sample Magnetometer, Mossbauer spectroscopy, ESR, NMR. Magneto-optic Kerr effect. Electrochemical Techniques: Cyclic voltammetry, Electrochemical Impedance, Scanning electrochemical Microscopy, The quartz crystal micro balance.

**REFERENCES**

**COURSE OUTCOMES**
Upon completing the course, the students will be able to
1. Understand the spectroscopic characterization techniques to investigate the properties of nano materials
2. Get the knowledge regarding various microscopic techniques available
3. Know the characterization techniques to analyse thermal characteristics of nano materials
4. Calculate the mechanical properties of nanomaterials using different characterization methods
5. Measure the magnetic and electrochemical properties of nanomaterials using various suitable techniques

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COURSE OBJECTIVE

- To introduce the various fabrication techniques available in the field of Nanotechnology
- To teach various lithographic techniques available for nanofabrication
- To impart the knowledge of nanofabrication process by charged beams
- To study the various scanning probes technology and application in the field of nanofabrication
- To teach the concept of Etching and pattern transfer techniques used in nanofabrication


**Nanofabrication by Scanning Probes**: Principles of SPMs-Exposure of Resists: Field Electron Emission-Exposure of Resist by STM-Exposure of Resist by NSOM; Local Oxidation Lithography-Additive Nanofabrication: Field-Induced Deposition-Dip-Pen Nanolithography; Subtractive Nanofabrication: Electrochemical Etching-Field-induced Decomposition-Thermomechanical Indentation-Mechanical Scratching

**Nanoscale Pattern Transfer**: Additive Pattern Transfer: Thin Film Deposition-Pattern Transfer by Lift-Off-Pattern Transfer by Plating-Damasocene Process-Pattern Transfer by Stencil Mask; Subtractive Pattern Transfer: Isotropic Wet Etching-Isotropic Wet Etching-Reactive-Ion Etching (RIE)-Process Control in Nanoscale RIE-RIE by Inductively Coupled Plasma-Critical Issues in RIE-Ion Milling.

**REFERENCES**

**COURSE OUTCOMES**
On successful completion of the course, the students will be able to
1. Get the knowledge of various fabrication techniques available in the field of Nanotechnology
2. Understand the concept and methods of lithographic techniques available for nanofabrication
3. Get the knowledge of nanofabrication process by charged beams
4. Get basic idea about various scanning probes technology and their application in the field of nanofabrication
5. Understand the concept of Etching and pattern transfer techniques used in nanofabrication

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**OE - OPEN ELECTIVES**

19EIMMOEXXX | OPTOELECTRONIC MATERIALS AND DEVICES | L | T | P | C | 3 0 0 3

**COURSE OBJECTIVES**
- To impart knowledge on Electronic properties of semiconductor materials for optoelectronic devices.
- To educate on basic structure and realization of Optoelectronic Devices and LEDs.
- To provide an overview on semiconductor LASER diodes and their application in optical fibre communication.
• To introduce the concepts and working of photo detectors and optoelectronic modulators


**P-N junction – the basic structure for optoelectronic device realization:**
Operation of various junctions including Schottky – barrier contacts – Heterojunctions and their importance to optoelectronic device fabrication – Solar cells.

**Light Emitting Diodes:** Operation of LEDs, their structures, and applications – Homojunctions and heterojunctions.

**Semiconductor Laser Diodes:** Operation of semiconductor laser diodes
semiconductor lasers – Types of semiconductor lasers – Multi quantum – well lasers – Beam characteristics and modulation of semiconductor lasers – Role of semiconductor lasers in modern fiber – optic communication systems.

**Photodetectors:** Operation of different types of photodetectors – Materials for the fabrication of photodetectors and their applications.

**Optoelectronic Modulators:** Electro – Optic effect (linear and quadrature) – Materials that exhibit the E-O effect – Fabrication of optoelectronic modulators (into practical light – intensity and/or phase modulators).

**REFERENCES**

**COURSE OUTCOMES**

Upon completing the course, the student should
1. Understand the basic concepts of Optoelectronic Materials and Devices.
2. Acquire the knowledge on basic structure and realization of Optoelectronic Devices, LEDs and acquire the working concepts of LEDs.
3. Understand the concepts and structure of semiconductor LASER diodes and their application in optical fibre communication.
4. Acquire the working knowledge of RF MEMS based reconfigurable antenna.
5. Understand the concepts working and application of photo detectors and optoelectronic modulators.

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**COURSE OBJECTIVES**

- To introduce the basic concepts of micro systems and advantages of miniaturization
- To teach the fundamentals of micromachining and micro fabrication techniques
- To train the students on the design of micro sensors and actuators and fabrication flow process.
- To impart knowledge on various packaging technologies for MEMS.


MEMS switches – Pull in and Pull out voltage analysis.


REFERENCES


COURSE OUTCOMES

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

1. Know the basic concepts of micro systems and advantages of miniaturization.
2. Understand the fundamentals of micromachining and micro fabrication techniques.
3. Design the solid models for microsystems.
4. Expertise the knowledge in design of micro sensors and actuators fabrication.
5. Develop various packaging techniques in the design of MEMS.

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AUDIT COURSES

19EIMMACXX ENGLISH FOR RESEARCH PAPER WRITING L T P C
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COURSE OBJECTIVES

Students will be able to:

- Understand that how to improve your writing skills and level of readability
- Learn about what to write in each section
- Understand the skills needed when writing a Title Ensure the good quality of paper at very first-time submission syllabus.
- Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the conclusion.

Useful phrases, how to ensure paper is as good as it could possibly be the first-time submission.

REFERENCES

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COURSE OBJECTIVES
Students will be able to:
- Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Critically understand the strengths and weaknesses of disaster management approaches, planning and programming.

Introduction Disaster
Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.

Repercussions Of Disasters And Hazards:
Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.
Disaster Prone Areas In India
Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics

Disaster Preparedness And Management
Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.

Risk Assessment

Disaster Mitigation Meaning
Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation In India.

REFERENCES

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COURSE OBJECTIVES
• Understand value of education and self-development
• Imbibe good values in students
• Let the should know about the importance of character


Importance of cultivation of values, Sense of duty, Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.


REFERENCES

COURSE OUTCOMES
Students will be able to
2. Learn the importance of Human values
3. Developing the overall personality

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<th>19EIMMACXX</th>
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COURSE OBJECTIVES
Students will be able to:
- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

History of Making of the Indian Constitution
History, Drafting Committee, (Composition & Working)

Philosophy of the Indian Constitution
Preamble, Salient Features

Contours of Constitutional Rights & Duties

Organs of Governance
Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

Local Administration
District’s Administration Head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.
**Panchayati Raj:** Introduction, PRI: ZilaPachayat, Elected officials and their roles, CEO ZilaPachayat: Position and role. Block level: Organizational Hierarchy (Different departments),

**Village level:** Role of Elected and Appointed officials, Importance of grass root democracy.

**Election Commission**
Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

**REFERENCES**
1. The Constitution of India, 1950 (Bare Act), Government Publication.

**COURSE OUTCOMES**
Students will be able to:
1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.

**PEDAGOGY STUDIES**

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<th>COURSE OBJECTIVES</th>
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<td>Students will be able to:</td>
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<td>• Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.</td>
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<td>• Identify critical evidence gaps to guide the development.</td>
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**Introduction and Methodology**

**Thematic overview**
Pedagogical practices are being used by teachers, in formal and informal classrooms in developing countries. Curriculum, Teacher education.

**Evidence on the effectiveness of pedagogical practices**
Methodology for the in depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and

Professional development: alignment with classroom practices and follow-up support, Peer support, Support from the head teacher and the community. Curriculum and assessment, Barriers to learning: limited resources and large class sizes.

**Research gaps and future directions**
Research design, Contexts, Pedagogy Teacher education, Curriculum and assessment, Dissemination and research impact.

**REFERENCES**

**COURSE OUTCOMES**
Students will be able to understand:
1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners.
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy.

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**COURSE OBJECTIVES**
1. To achieve overall health of body and mind
2. To overcome stress
   Definitions of Eight parts of yog. (Ashtanga)
   Yam and Niyam
   Do’s and Don’t’s in life.
i) Ahinsa, satya, astheya, bramhacharya and aparigraha  
ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan  
Asan and Pranayam  
  i) Various yog poses and their benefits for mind & body  
  ii) Regularization of breathing techniques and its effects - Types of pranayam  

REFERENCES  
1. “Yogic Asanas for Group Tarining-Part-I” :Janardan Swami Yogabhyasi Mandal, Nagpur  
2. “Rajayoga or conquering the Internal Nature” by Swami Vivekananda, AdvaitaAshrama (Publication Department), Kolkata.  

COURSE OUTCOMES  
Students will be able to:  
  1. Develop healthy mind in a healthy body thus improving social health also  
  2. Improve efficiency  

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<th>PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS</th>
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COURSE OBJECTIVES  
  1. To learn to achieve the highest goal happily  
  2. To become a person with stable mind, pleasing personality and determination  
  3. To awaken wisdom in students  

Neetisatakam-Holistic development of personality  
• Verses- 19,20,21,22 (wisdom)  
• Verses- 29,31,32 (pride & heroism)  
• Verses- 26,28,63,65 (virtue)  
• Verses- 52,53,59 (don’ts)  
• Verses- 71,73,75,78 (do’s)  

Approach to day to day work and duties  
Shrimad BhagwadGeeta : Chapter 2-Verses 41, 47,48,  
Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,  
Chapter 18-Verses 45, 46, 48.  
Statements of basic knowledge.  
Shrimad BhagwadGeeta:  
Chapter2-Verses 56, 62, 68  
Chapter 12 -Verses 13, 14, 15, 16,17, 18  
Personality of Role model. Shrimad BhagwadGeeta:  
Chapter2-Verses 17, Chapter 3-Verses 36,37,42,  
Chapter 4-Verses 18, 38,39  
Chapter18 – Verses 37,38,63
REFERENCES
1. “Srimad Bhagavad Gita” by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata
2. Bhartrihari’s Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

COURSE OUTCOMES
Students will be able to:
1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.