ANNAMALAI UNIVERSITY
DEPARTMENT OF ELECTRONICS AND INSTRUMENTATION ENGINEERING

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 sate 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 carrier.

M.E. MICROELECTRONICS AND MEMS

PROGRAMME EDUCATIONAL OBJECTIVES

1. To provide a pool of post graduate engineers who are specialists in the modeling and design of basic and advanced semiconductor devices.
2. 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.
3. 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.
4. To train engineers who would design and develop nano electronic circuits and nano electro mechanical systems for the future world.
5. To inculcate students a professional approach to problem solving, using analytical, academic, and communication skills effectively, with special emphasis on working in teams.

6. 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.

7. 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 nano-structures 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.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
PEO1	√	√	√					√	
PEO2				√	√	√	√		
PEO3						√			
PEO4			√					√	
PEO5	√	√	√	√					
PEO6								√	√
PEO7				√					√

ANNAMALAI UNIVERSITY
FACULTY OF ENGINEERING AND TECHNOLOGY
M.E. / M. Tech (Two-Year Full Time & Three-year Part Time) DEGREE PROGRAMME
CHOICE BASED CREDIT SYSTEM (CBCS)
REGULATIONS

1. **Condition 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.Techdegree of Annamalai University or any other authority accepted by the syndicate of this University as equivalent thereto. They shall satisfy the condition regarding qualifying marks and physical fitness as may be prescribed by the syndicate of the AnnamalaiUniversity from time to time. The admission for 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.
2. **Branches of Study in M.E / M.Tech**
   The Branch and Eligibility criteria of programmes are given in **Annexure 1**
3. **Courses of study**

The courses of study and the respective syllabi for each of the M.E / M. Tech programmes offered by the different Departments of study are given separately.

4. **Scheme of Examinations**
   The scheme of Examinations is given separately.
5. **Choice Based Credit System (CBCS)**
   The curriculum includes three components namely Professional Core, Professional Electives and Open Electives in addition toThesis. Each semester curriculum shall normally have a blend of theory and practical courses.
6. **Assignment of Credits for Courses**
   Each course is normally assigned one credit per hour of lecture / tutorial per week and one credit for two hours or part thereof for laboratory or practical per week.The total credits for the programme will be 65.
7. **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.
8. **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 II shall be done at the appropriate semesters.
9. **Electives**
   The student has to select two electives in first semester and another two electives in the second semester from the list of Professional Electives. The student has to select two electives in third semester from the list of Open Electives offered by the department/ allied department. A student may be allowed to take up the open elective courses of third semester (Full Time program) in the first and second semester, one course in each of the semesters to

enable them to carry out thesis in an industry during the entire second year of study provided they should register those courses in the first semester itself. Such students should meet the teachers offering those elective courses themselvesfor clarifications. No specific slots will be allotted in the time table for such courses.

Further, the two open elective courses to be studied in III semester (Full Time programme) may also be credited through the SWAYAM portal of UGC with the approval of Head of the Department concerned. In such a case, the courses must be credited before the end of III Semester.

10. Assessment

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

First assessment (Mid-Semester Test-I)	:	10 marks
Second assessment (Mid-Semester Test-II)	:	10 marks
Third Assessment	:	5 marks
End Semester Examination	:	75 marks

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

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.

11. Student Counsellors (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 counsellor for those students throughout their period of study. Such student counsellors shall advise the students, give preliminary approval for the courses to be taken by the students during each semester, monitor their progress in SWAYAM courses / open elective courses and obtain the final approval of the Head of the Department.

12. Class Committee

For each of the semesters of M.E / M.Techprogrammes, 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 / 40 marks for practical and project work 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 anddeclaration 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 65 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 65 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 65 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.Techdegree 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.

ANNEXURE 1

S.No.	Department		Programme (Full Time & Part time)	Eligible B.E./B.TechProgramme *
1	**Civil Engineering**	i.	Environmental Engineering	B.E. / B.Tech – Civil Engg, Civil & Structural Engg, Environmental Engg, Mechanical Engg, Industrial Engg, Chemical Engg, BioChemicalEngg, Biotechnology, Industrial Biotechnology, Chemical and Environmental Engg.
		ii.	Environmental Engineering & Management	
		iii.	Water Resources Engineering & Management	B.E. / B.Tech – Civil Engg, Civil & Structural Engg, Environmental Engg, Mechanical Engg, Agricutural and irrigation Engg, Geo informatics, Energy and Environmental Engg.
2	**Civil & Structural Engineering**	i.	Structural Engineering	B.E. / B.Tech – Civil Engg, Civil & Structural Engg.
		ii.	Construction Engg. and Management	
		iii.	Geotechnical Engineering	
		iv.	Disaster Management &Engg.	
3	**Mechanical Engineering**	i.	Thermal Power	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Mechanical Engg (Manufacturing).
		ii.	Energy Engineering & Management	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Mechanical (Manufacturing) Engg, Chemical Engg
4	**Manufacturing Engineering**	i.	Manufacturing Engineering	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Manufacturing Engg, Production Engg, Marine Materials science Engg, Metallurgy Engg, Mechatronics Engg and Industrial Engg.
		ii.	Welding Engineering	
		iii.	Nano Materials and Surface Engineering	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Manufacturing Engg, Production Engg, Marine Materials science Engg, Metallurgy Engg, Chemical Engg
5	**Electrical Engineering**	i.	Embedded Systems	B.E. / B.Tech – Electrical and Electronics Engg, Control and Instrumentation Engg, Information technology, Electronics and communication Engg, Computer Science and Engg
		ii.	Smart Energy Systems	B.E. / B.Tech – Electrical and Electronics Engg, Control and Instrumentation Engg, Electronics and communication Engg.
		iii.	Power System	

6	**Electronics & Instrumentation Engineering**	i.	Process Control & Instrumentation	B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and ElectornicsEngg, Control and Instrumentation Engg, Instrumentation Engg
		ii.	Rehabilitative Instrumentation	B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and ElectornicsEngg, Electronics and communication Engg, Control and Instrumentation Engg, Instrumentation Engg, Bio Medical Engg, Mechatronics.
		iii.	Micro Electronics and MEMS	B.E. / B.Tech – B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and ElectornicsEngg, Electronics and communication Engg, Control and Instrumentation Engg, Instrumentation Engg, Bio Medical Engg, Mechatronics, Telecommunication Engg
7	**Chemical Engineering**	i.	Chemical Engineering	B.E. / B.Tech – Chemical Engg, Petroleum Engg, Petrochemical Technology
		ii.	Food Processing Technology	B.E. / B.Tech - Chemical Engg, Food Technology, Biotechnology, Biochemical Engg, Agricultural Engg.
		iii.	Industrial Bio Technology	B.E. / B.Tech - Chemical Engg, Food Technology, Biotechnology, Leather Technology
		iv.	Industrial Safety Engineering	B.E. / B.Tech – Any Branch of Engineering
8	**Computer Science & Engineering**	i.	Computer Science & Engineering	B.E. / B.Tech - Computer Science and Engineering, Information Technology, Electronics and Communication Engg, Software Engineering
9	**Information Technology**	I	Information Technology	B.E. / B.Tech - Computer Science and Engineering, Information Technology, Electronics and Communication Engg, Software Engineering
10	**Electronics & Communication Engineering**	i.	Communication Systems	B.E. / B.Tech -Electronics and Communication Engg, Electronics Engg.

*** AMIE in the relevant discipline is considered equivalent to B.E**

DEPARTMENT OF ELECTRONICS and INSTRUMENTATION ENGINEERING
Curriculum for M.E. (Microelectronics and MEMS) - Full Time

Sl. No.	Cate gory	Course Code	Course	L	T	P	CA	FE	Total	Credits
S e m e s t e r – I										
1	PC-I	MEMC101	Finite Element Analysis for MEMS	4		-	25	75	100	3
2	PC-II	MEMC102	Semiconductor Devices and Modelling	4		-	25	75	100	3
3	PC-III	MEMC103	VLSI Fabrication Techniques	4		-	25	75	100	3
4	PC-IV	MEMC104	Micromachining Techniques	4		-	25	75	100	3
5	PE-I	MEME105	Professional Elective – I	4		-	25	75	100	3
6	PE-II	MEME106	Professional Elective – II	4		-	25	75	100	3
7	PC Lab-I	MEMP107	Semiconductor Devices & VLSI Process Simulation Laboratory	-	-	3	40	60	100	2
			Total	**24**	**-**	**3**	**190**	**510**	**700**	**20**

Sl. No.	Cate gory	Course Code	Course	L	T	P	CA	FE	Total	Credits
S e m e s t e r – II										
1	PC-V	MEMC201	MOS Devices and Modelling	4	-	-	25	75	100	3
2	PC-VI	MEMC202	MEMS Sensors and Actuators	4	-	-	25	75	100	3
3	PC-VII	MEMC203	Nanomaterials and Nanoelectronics	4	-	-	25	75	100	3
4	PC-VIII	MEMC204	Analog Integrated Circuit Design	4	-	-	25	75	100	3
5	PE-III	MEME205	Professional Elective – III	4	-	-	25	75	100	3
6	PE-IV	MEME206	Professional Elective – IV	4	-	-	25	75	100	3
7	PC Lab-II	MEMP207	MEMS Simulation Laboratory	-	-	3	40	60	100	2
8	Seminar	MEMS208	Seminar	-	-	2	100	-	100	1
			Total	**24**	**-**	**5**	**290**	**510**	**800**	**21**

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits
S e m e s t e r – III										
1	OE-I	MEME301	Open Elective – I	4	-	-	25	75	100	3
2	OE-II	MEME302	Open Elective – II	4	-	-	25	75	100	3
3	Thesis	MEMT303	Thesis Phase-I	-	4	-	40	60	100	4
4	Ind. Training	MEMI304	Industrial Training		*	-	100	-	100	2
			Total	**8**	**4**	**-**	**190**	**210**	**400**	**12**

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

Sl. No.	Category	Course Code	Course	L	T	P	FE	CA	Total	Credits
S e m e s t e r – IV										
1	Thesis	MEMT401	Thesis Phase-II	-	8	-	40	60	100	12
			Total	**-**	**8**	**-**	**40**	**60**	**100**	**12**

L- Lecture ; **P-** Practical; **T-** Thesis; **CA-** Continuous Assessment; **FE-** Final Examination

DEPARTMENT OF ELECTRONICS and INSTRUMENTATION ENGINEERING
Curriculum for M.E.(Microelectronics & MEMS) – Part Time

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
Semester – I											
1	PC-I	PMEMC 101	Semiconductor Devices and Modelling	4	-	-	25	75	100	3	MEMC 101
2	PC-II	PMEMC 102	VLSI Fabrication Techniques	4	-	-	25	75	100	3	MEMC 102
3	PC-III	PMEMC 103	Micromachining Techniques	4	-	-	25	75	100	3	MEMC 103
			Total	**12**	**-**	**-**	**75**	**225**	**300**	**9**	

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
Semester – II											
1	PC-IV	PMEMC 201	MOS Devices and Modelling	4	-	-	25	75	100	3	MEMC 201
2	PC-V	PMEMC 202	MEMS Sensors and Actuators	4	-	-	25	75	100	3	MEMC 202
3	PC-VI	PMEMC 203	Nanomaterials and Nanoelectronics	4	-	-	25	75	100	3	MEMC 203
			Total	**12**	**-**	**-**	**75**	**225**	**300**	**9**	

Sl. No.	Cate gory	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equiva lent Course Code in M.E. Full Time
Semester – III											
1	PC-VII	PMEMC 301	Finite Element Analysis for MEMS	4	-	-	25	75	100	3	MEMC 104
2	PE-I	PMEME 302	Professional Elective – I	4	-	-	25	75	100	3	MEME 105
3	PE-II	PMEME 303	Professional Elective – II	4	-	-	25	75	100	3	MEME 106
4	PC Lab-I	PMEMP 304	Semiconductor Devices & VLSI Process Simulation Laboratory	-	-	3	40	60	100	2	MEMP 107
			Total	**12**	**-**	**3**	**115**	**285**	**400**	**11**	

Sl. No.	Cate gory	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equiva lent Course Code in M.E. Full Time
Semester – IV											
1	PC-VIII	PMEMC 401	Analog Integrated Circuit Design	4	-	-	25	75	100	3	MEMC 204
2	PE-III	PMEME 402	Professional Elective – III	4	-	-	25	75	100	3	MEME 205
3	PE-IV	PMEME 403	Professional Elective – IV	4	-	-	25	75	100	3	MEME 206
4	PC Lab-II	PMEMP 404	MEMS Simulation Laboratory	-	-	3	40	60	100	2	MEMP 207
5	Semi nar	PMEMS 405	Seminar		-	2	100		100	1	MEMS 208
			Total	**12**	**-**	**5**	**215**	**285**	**500**	**12**	

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
Semester – V											
1	OE-I	PMEME 501	Open Elective – I	4	-	-	25	75	100	3	MEME 301
2	OE-II	PMEME 502	Open Elective – II	4	-	-	25	75	100	3	MEME 302
3	Thesis	PMEMT 503	Thesis Phase-I	-	4	-	40	60	100	4	MEMT 303
4	Ind. Training	PMEMI 504	Industrial Training		*	-	100		100	2	MEMI 304
			Total	**8**	**4**	**-**	**190**	**210**	**400**	**12**	

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

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
Semester – VI											
1	Thesis	PMEMT 601	Thesis Phase-II	-	8	-	40	60	100	12	MEMT 401
			Total	**-**	**8**	**-**	**40**	**60**	**100**	**12**	

L- Lecture ; **P-** Practical; **T-** Thesis; **CA-** Continuous Assessment; **FE-** Final Examination

Sl. No	PROFESSIONAL ELECTIVES
1	RF MEMS
2	Semiconductor Power Devices and modelling
3	Polysilicon Technology
4	Microfluidics and Bio MEMS
5	VLSI Design
6	Digital Integrated Circuit Design
7	Advanced VLSI System Design
8	Fundamentals of IC Packaging, Assembly and Test
9	Mixed Signal IC Design
10	Digital System Design with HDL (Verilog)

S.No	OPEN ELECTIVES
1	Optoelectronic Materials and Devices
2	MEMS Design and Fabrication

MEMC101	FINITE ELEMENT ANALYSIS FOR MEMS	L	T	P
		4	0	0

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.

ANSYS - Introduction, Build ANSYS Model for one dimensional and two dimensional elements, plane stress problem, thermal problem, electromagnetic problem, dynamic problem and a model for CFD problem. FE modelling and analysis of Microelectro-Mechanical Systems [MEMS] using ANSYS. Coupled Field Analysis. Modelling mass, and condensation technique. Build ANSYS Model for a MEMS problem.

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3. **Chandrupatla, R. T. and Belegundu, A. D.**, Introduction to Finite Elements in Engineering, Second Edition, *Prentice Hall of India*, 1997.
4. **Moaveni, S.,** Finite Element Analysis: Theory and Application with ANSYS, *Prentice Hall Inc*., 1999.
5. **J.N. Reddy**, Introduction to the Finite Element Method, *McGraw Hill Publishers*, 2nd

Edition.
6. **K.J. Bathe,** Finite Element Procedures in Engineering Analysis, *Prentice Hall*, 2nd Edition, 1997.

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

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1					✓	✓			
CO2				✓	✓	✓			✓
CO3				✓	✓	✓			✓
CO4				✓	✓	✓			✓
CO5				✓	✓	✓			✓

MEMC102	SEMICONDUCTOR DEVICES AND MODELLING	L	T	P
		4	0	0

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 Semiconductors: Atomic picture of Silicon and Germanium – Electric current, free electron density and mobility in Semiconductors - Effect of doping on minority carrier density in Semiconductors – Energy band picture of P and N type Semiconductors – Temperature dependence of conductivity – Degeneracy. Calculation of free electron density and hole density in a Semiconductor – Determination of position of Fermi level for a given Semiconductor – Carrier density expressed in terms of departure of Fermi level from intrinsic Fermi level – Fermi level in N-type and P-type samples as measured from intrinsic Fermi level – Very lightly doped samples – representation of energy band diagram in terms of potential – Equation governing potential distribution in a Semiconductor – Equation governing distribution of hole density and electron density – Continuity equation for Semiconductors – Determination of steady state excess carrier density – Concepts of Quasi Fermi level.

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 – P-N junction behavior in terms of minority carrier stored charge – Calculation of electric field and voltage drop in the bulk.

Quantitative analysis of Bipolar Junction Transistor: Operation of a BJT – Performance parameters – Effect of collector junction voltage on current – Dependence of I_C on V_E and I_E. Uniform Base PNP transistor with Forward biased B-E junction and Reverse biased C-B junction – Calculation of performance parameters – Transit time of minority carriers through base – Effect of floating collector on transistor V - I characteristics – Effect of floating emitter junction characteristics – Collector current with base floating – Temperature effects in Transistors – Effect of device geometry on the transistor performance – Ebermoll's equation.

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:

1. **M.K. Achuthan and K. N. Bhat**, Fundamentals of Semiconductor devices, *Tata McGraw Hill*, New Delhi, 2007.
2. **Ben G Streetman**, Solid State Electronics, *Prentice Hall*, 1999.
3. **S.M.Sze**, Modern Semiconductor Devices Physics, *John Wiley and Sons*, 1998.
4. **Donald A. Meamen**, Semiconductor Physics and Devices – Basic Principles, McGraw Hill, 2003.

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.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9

CO1	✓	✓	✓						
CO2	✓	✓	✓						
CO3	✓	✓	✓						
CO4	✓	✓	✓						
CO5	✓	✓	✓						✓

MEMC103	**VLSI FABRICATION TECHNIQUES**	**L**	**T**	**P**
		4	**0**	**0**

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 source – Two step diffusion. Diffusion systems – Choice of dopant source – Diffusion systems for Silicon – Special problems in Silicon diffusion – Redistribution ohmic oxide growth – Emitter push effect.

Thermal oxidation of Silicon: Oxide formation – Kinetics of Oxide growth – Initial growth phase – Doping dependence effects – Orientation dependence effects - Oxidation systems – Properties of thermal oxides – Anodic oxidation – Oxide growth in anodic oxidation – Properties of anodic oxides.

Wet chemical etching: Isotropic etching – Anisotropic etching – Etching of crystalline materials – Silicon etching using HNO_3, KOH, TMAH and EDP etching – SiO_2 etching – PSG etching – Silicon Nitric etching – Poly Silicon etching – Plasma etching - Wafer cleaning.

Lithographic Process: Optical techniques – E-beam techniques – Printing and engraving – Optical printing – Lift-off techniques – Photo resist – Mask defects – Printing and engraving defect. Ion implantation: Penetration range – Nuclear stoping - Implantation domestic – Annealing - Ion implantation systems. PolySilicon deposition using LPCVD – PECVD techniques – Metallization – Process flow for BJT fabrication – Process flow for self aligned MOSFET fabrication – Process flow for SOI MOSFET fabrication.

REFERENCES:

1. **Sorab. K.Ghandhi**, VLSI Fabrication Principles, Wiley Inter Science Publication, New York, 1994.
2. **Sami Franssila**, Introduction to Microfabrication, John Wiley and Sons, 2004.
3. **Sze. S.M**, VLSI Technology, McGraw Hill Publishers, 1988.
4. **Sze. S.M**, ULSI Technology, McGraw Hill Publishers, 1996.

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.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓			✓					✓
CO2	✓	✓		✓					✓
CO3	✓	✓	✓				✓	✓	✓
CO4			✓		✓	✓		✓	✓
CO5			✓	✓			✓	✓	✓

		L	T	P
MEMC 104	**MICROMACHINING TECHNIQUES**	**4**	**0**	**0**

COURSE OBJECTIVES:

- To study the various materials used for micromachining techniques.
- To understandthe process of Bulk Micro Machiningtechniques.
- To understand the process of Surface Micromachining techniques.
- To study the process of bonding techniques.
- To provide the significance of sacrificial process.

Introduction to micro machined devices: Materials for micromachining-micromachining term-mechanical properties of silicon-native oxides of silicon and other semiconductors-typical silicon wafer types.

Bulk Micro Machining: wet etching of silicon-Isotropic etching-anisotropic etching-alkali hydroxide etchants-ammonium hydroxide-tetra methyl ammonium hydroxide (TMAH)-ethylene diamine pyrochatechol (EDP)-ultrasonic agitation in wet etching- stop layers for dopant elective etchants. Porous-silicon formation –anistrophic wet etching of porous aluminum-anistrophic wet etching - quartz-vapour phase etches. RLE-laser driven bulk processing.

Surface Micromachining: Thin film processes-nonmetallic thin film for micromachining –silicon dioxide – silicon nitride - silicon carbide - polycrystalline diamond - polysilicon and other semiconductors and thin film transition – wet etching of non-metallic thin film-metallic thin film for micromachining - Resistive evaporation – E - beam evaporation-sputter deposition-comparison of evaporation 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: -Vapour phase sacrificial layer etch - sealed cavity formation-sharp tip formation-chemical mechanical polishing-electric charge machining (ECM)-photosensitive glass micromachining focused on beam micromachining.

REFERENCES:

1. **Gregory T.A. Kovacs**, Micromachined Transducers, *WCB McGraw Hill*, 1998.
2. **Chang Liu,** Foundation of MEMS, (Illinois ECE series), *Pearson Educational International*, 2006.
3. **S.M. Sze**, Semiconductor Sensors, *John Wiley and Sons*, 1994.
4. **N.P. Mahalik**, MEMS, *Tata McGraw Hill*, 2007
5. **Sami Franssila**, Introduction to Microfabrication, *John Wiley and Sons,* 2004

COURSE OUTCOMES:

Upon completing the course, the student should have

1. Thorough knowledge of materials used for micromachining techniques.
2. Understood the process of Bulk Micro Machining techniques.
3. Understood the process of Surface Micro Machining techniques.
4. Understood the process of bonding techniques.
5. Understood the sacrificial process and other special techniques.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1							✓		
CO2		✓	✓	✓					
CO3		✓	✓	✓					
CO4		✓	✓	✓					
CO5								✓	✓

MEMP107	SEMICONDUCTOR DEVICES & VLSI PROCESS SIMULATION LABORATORY	L	T	P
		0	0	3

LIST OF EXPERIMENTS

1. Discrete energy levels possessed by electrons in an isolated atom.
2. Temperature dependence of intrinsic carrier concentration in semiconductor.
3. Electron and hole concentration in semiconductor doped at different levels.
4. Conductivity and resistivity of semiconductor doped at different levels.
5. Temperature effects on the probability of occupation of energy levels in a semiconductor.
6. Effect of Doping concentration on the contact potential (Vcp) in a P-N junction semiconductor diode.
7. Determination of the forward and reverse characteristics of a P-N junction diode parameter like conductivity of P and N region and their Dimension.
8. Estimation of BJT performance parameters (α, β, γ) for a given device.
9. Analysis of the collector current in P+-N-P and N+-P-N transistors for different device parameters.
10. Simulation studies on diffusion process and estimation of diffusivity at different temperatures.

MEMC201	MOS DEVICES AND MODELLING	L	T	P
		4	0	0

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 aboutshort 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.

SOI 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 $MESFET_S$ - pinch off voltage and threshold voltage- MESFET modelling.

REFERENCES:

1. **Achuthan.M.K. and Bhat.K. N.,** Fundamentals of Semiconductor devices, *Tata McGraw Hill*, New Delhi, 2007.
2. **Nandita Dasgupta and Amitava Dasgupta**, Semiconductors Devices Modelling and Technology, *Prentice Hall India,* 2004.
3. **Narain Arora**, MOSFET Models for VLSI Circuits Simulation – Theory and Practice, *Springer Verlag*, New York, 1993.
4. **Sze. S.M.,** Modern Semiconductor Devices Physics, *John Wiley and Sons*, 1998.
5. **Ben G Streetman**, Solid State Electronics, *Prentice Hall*, 1999.

COURSE OUTCOMES:

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

- Know the basic concepts of MOS structure under different modes of operation and characteristics
- Understand the fundamentals on solving the problem based on MOS structure
- Expertise the knowledge in fundamentals of MOSFET Operation under various SPICE level models and problem solving
- Understand the design concepts about short and long channel effects
- Acquire knowledge on the SOI MOSFETS and High Speed Devices

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓	✓						
CO2				✓					
CO3						✓			
CO4				✓					
CO5							✓	✓	✓

MEMC 202	MEMS SENSORS AND ACTUATORS	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To impart knowledge on basic mechanics and properties of materials.
- To studythe architecture of various MEMS pressure sensors, MEMS accelerometers and Microphones.
- To studythe architecture of various MEMS actuators and their industrial applications.
- To introduce the knowledge of Optical MEMS and their allied devices.
- To studythe principles of various thermal sensors and actuators.

Basic Mechanics: Axial stress and strain – Shear stress and strain – Poisson's ratio – Commonly used deflection equations for micro structures – static beam equations – static torsion equations – Dynamics. **Mechanical properties of materials:** Material failure – Mechanical characterization of thin films – Direct measurement of Young's modulus – Poisson's ratio and tensile strength.

MEMS Pressure sensors: Sensing mechanisms – MEMS Pressure sensors – Types of pressure sensors – Piezo resistive pressure sensors – V-grove etching – Surface micro machined pressure sensors using Poly Silicon Piezo resistors – Overload protection – Capacitive pressure sensors – Resonant pressure sensors. **MEMS accelerometers** – Basic accelerometer concepts – Force balance accelerometers – Strain gauged accelerometers – Capacitive accelerometers – Force balance capacitive accelerometers – Piezoelectric accelerometers. **Microphones** - Piezo resistive microphones –capacitive microphones –Piezoelectric microphones– Moving gate FET microphones – Tactile sensors and their types.

MEMS Actuators and their applications: Actuation mechanisms – Electrostatic actuation – Electrostatic cantilever actuators – Torsional electrostatic actuators – Electrostatic comb drives – Feedback stabilization of electrostatic actuators - Electrostatic rotary micro motors - Electrostatic linear micro motors – Electrostatic micro grippers – Electrostatic relays and switches - Thermal actuation – Thermal expansion of solids – Thermal array actuators –Piezoelectric actuation – Cantilever resonators.

Optical MEMS: Fundamental principles of MOEMS technology – Review on properties of light – Light modulators – Beam splitter – Micro lens – Micro mirror – Digital Micro mirror – Light detectors – Grating light value – Optical switch – Shear and stress measurement .

Thermal sensors and actuators: Thermal energy basics and heat transfer – Thermocouple – Micromachined thermocouple – Peltier effect heat pumps – Thermal flow sensors – Micro hot plate gas sensors – Thermally activated MEMS relay. Magnetic materials for MEMS – MEMS magnetic sensor – MEMS magnetic pressure sensor – Magnetic microactuator

REFERENCES:

1. **Gregory T.A. Kovacs**, Micromachined Transducers, *WCB McGraw Hill*, 1998.
2. **S.M. Sze**, Semiconductor Sensors, *John Wiley and Sons*, 1994.
3. **N.P. Mahalik**, MEMS, *Tata McGraw Hill*, 2007.
4. **Stephen D. Senturia,** Micro system Design, Springer International Edition, 2001.

COURSE OUTCOMES:
Upon completing the course, the student should have

1. Understood basic mechanics and material properties.
2. The capacity to design the structure of MEMS pressure sensors, MEMS accelerometers and Microphones.
3. Know the structural designof MEMS actuators suitable for specific industrial applications.
4. Understood the principles of Optical MEMS used in various light sensitive devices.
5. Acquired the knowledge of thermalsensors and actuatorsused in industrial applications.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	✓			✓				
CO2			✓	✓	✓			
CO3			✓	✓	✓			
CO4			✓	✓				✓
CO5				✓			✓	

		L	T	P
MEMC203	**NANO MATERIALS AND NANO ELECTRONICS**	**4**	**0**	**0**

COURSE OBJECTIVES:

- To impart knowledge on Nanomaterials, its present applications, Atom, Clusters and its importance.
- To educate on Synthesis / Preparation of nanomaterials.
- To provide an overview on influence of scaling of size on material properties.
- To introduce the concepts of Quantum size effect, quantum wells, quantum wires and quantum dots.
- To give an overview of the future applications of Nanomaterials.

Introduction to nanomaterials and nanotechnology: History of nanomaterials - Influence on properties by nano - structure induced effects - Some present and future applications of Nanomaterials. **Atoms, clusters and nanomaterials:** Introduction - importance of clusters.

Preparation/Synthesis of nanomaterials: Methods for creating nanostructures - Processes for producing ultrafine powders - Chemical Synthesis - Physical Synthesis – Bio mimetic processes.

Mechanical and Magnetic Properties of materials due to the scaling of size: Mechanical - Introduction - Property changes due to nanostructuring - Strengthening and Toughening Mechanisms - Chemical - Sensors - catalysis - Magnetic - Magnetic Properties of small atomic clusters - Importance of nano-scale magnetic materials - Classifications of magnetic nanomaterial.

Optical Properties and Quantum Size Effect - Absorption of light in semiconductor materials - Optical properties of a translucid object - Effective medium theory - Electronic - Quantum size effect in metal or semiconductor nanoparticles - Quantum Wells, Wires and Dots - Single Electronics.

Future applications including bottom-up nanotechnology and microelectronics: The red brick wall in microelectronics - Future needs of microelectronics industries Review of possible bottom up approaches still in research - Self organization.

REFERENCES:

1. **Fendler J.H**, Nanoparticles and Nanostructured Films: Preparation, Characterization and Applications, ISBN: 3527294430, *Wiley VCH*, 1998.
2. **Klabunde K.J**, Nanoscale Materials in Chemistry, *John Wiley and Sons*,2001.
3. **Wang Z.L**, Characterization of Nanophase Materials, *Wiley-VCH Verlag GmbH*, 2000.
4. **Journals/Magazines/Websites**

http://www.nanotech-now.com/
http://www.foresight.org/

COURSE OUTCOMES:

Upon completing the course, the student should

1. Understand Nanomaterials, the basic concepts of atoms, clusters and its importance.
2. Acquire the concepts behind preparation and synthesis of Nanomaterials.
3. Understand the influence of scaling of size on different properties of nanomaterials.
4. Understand Quantum size effect, quantum wells, quantum wires and quantum dots.
5. Understand the future applications of Nanomaterials.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓	✓						
CO2				✓					
CO3						✓			
CO4				✓					
CO5							✓	✓	✓

MEMC204	ANALOG INTEGRATED CIRCUIT DESIGN	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To introduce on analog integrated circuit design and various CAD tools.
- To review MOSFET fabrication, models, secondary effects and their influence on analog circuits design.
- To teach the design of MOS based switches, current mirrors and amplifiers
- To make the students understand various MOS based op-amp configurations and their biasing.
- To educate the concepts of comparators, switched capacitors, analog filters and A/D converters using MOSFETs.

Introduction: Course overview - Analog IC design: CAD tools and methodology - Notations, symbols, and terminology - Example of analog signal processing and analog ICs - Review of IC technology, device modeling and layout: Modeling of BJT and MOS devices - BJT and MOS fabrication technology- Basic IC layout and passive components.

Basic analog sub circuits: MOS switch and resistor - Current sources/sinks and current mirrors - Design of basic amplifiers - Current and voltage references - **Noise analysis and modeling:** Time and frequency-domain analysis - Noise models for IC devices – Noise analysis examples.

Basic operational amplifier (op amp) design: Non-ideal characteristics of op amp - Design of two-stage op amps - Stability and frequency compensation - **Advanced operational amplifiers:** Buffered op amps - Folded-cascaded, rail-to-rail input, and class-AB input op amps - Fully-Differential op amps and Common-Mode Feedback Circuits

Comparators: Characterization of comparator - Bipolar Comparators - CMOS Comparators - Integrated filters: Op amp-RC filters - MOSFET-C filters - Gm-C filters - Switched - capacitor filters

Introduction to data converters : Characterization and definition of data converters - Nyquist – Rate - Digital - to - Analog Converters - Nyquist-Rate Analog – to - Digital Converters - Oversampled Converters

REFERENCES:

1. **BehzadRazavi**, Design of Analog CMOS Integrated Circuit, *McGraw-Hill*, 1999.
2. **P. E. Allen and D. R. Holberg**, CMOS Analog Circuit Design, second edition, *Oxford University Press*, 2002.
3. **D. A. Johns and K. Martins**, Analog Integrated Circuit Design, *John Wiley and Sons Inc*., 1997.
4. **P.R. Gray, P. J. Hurst, S. H. Lewis, and R.G. Meyers**, Analysis and Design of Analog Integrated Circuits, 4th Edition, *John Wiley and Sons Inc*., New York, 2001.
5. **K. R. Laker and W. M. C. Sansen**, Design of Analog Integrated Circuits and Systems, *McGraw Hill*, 1994.

COURSE OUTCOMES:

Upon completing the course, the student should have

1. Understood the concept of MOSFET based analog IC design.
2. Acquired the expertise on the tools and methodologies used in analog IC design.
3. Understood the design of basic differential amplifiers and issues to be addressed in the design of high performance op-amps.
4. The ability to test and analyse the performance characteristics of Analog Integrated Circuit.
5. Acquired the complete knowledge of the design of comparators, switched capacitor based analog circuits and analog to digital converters .

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓	✓						
CO2							✓	✓	✓
CO3							✓	✓	✓
CO4			✓				✓	✓	✓
CO5			✓				✓	✓	✓

MEMP207	MEMS SIMULATION LABORATORY	L	T	P
		0	0	3

LIST OF EXPERIMENTS

1. Study of IntelliSuite Software for the design and fabrication process of MEMS devices.
2. Deflection Response of SOI (Silicon-On-Insulator) Pressure Sensor.
3. Construction and Simulation of RF Switch.
4. Determination of Capacitance change in Capacitive Pressure Sensor.
5. Studies on effect of Air Gap on Pull - in Voltage of Cantilever beam employed RF Switch.
6. Estimation of Resistance change in SOI Piezo-resistive Pressure Sensor.
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.

MEMS208	SEMINAR	L	T	P
		0	0	2

COURSE OBJECTIVES

- To work on a technical topics related to microelectronics and MEMS and acquire the ability of written and oral presentation.
- To acquire the ability of writing technical papers for Conferences and Journals.

The students will work for two periods per week guided by student counsellor. They will be asked to present a seminar of not less than fifteen minutes and not more than thirty minutes on any technical topic of student's choice related to their specialization in Process Control and Instrumentation Engineering and to engage in discussion with audience. They will defend their presentation. A brief copy of their presentation also should be submitted. Evaluation will be done by the student counselor based on the technical presentation and the report and also on the interaction shown during the seminar.

COURSE OUTCOMES

1. The students will be getting the training to face the audience and to interact with the audience with confidence.
2. To tackle any problem during group discussion in the corporate interviews.

MEMT303	THESIS PHASE – I	L	T	P
		0	0	15

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
2. Learn to adopt systematic and step-by-step problem solving methodology

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓					✓	✓	✓	✓
CO2		✓	✓	✓	✓	✓		✓	✓

MEMI304	INDUSTRIAL TRAINING	L	T	P
		0	0	2

COURSEOBJECTIVES

- To train the students in the field work related to microelectronics and MEMS and to have a practical knowledge in carrying out microelectronics and MEMS 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 Process Control and Instrumentation.

MEM401	THESIS PHASE – II	L	T	P
		0	0	15

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.
2. Learn to adopt systematic and step-by-step problem solving methodology.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓					✓	✓	✓	✓
CO2		✓	✓	✓	✓	✓		✓	✓

MEMEX0X	**RF MEMS**	**L**	**T**	**P**
		4	**0**	**0**

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^{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_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_a band micromachined cavity oscillator

REFERENCES:

1. **Santos Hector J.D.L**, RF MEMS circuit design for wireless communication, *Artech house,* MEMS series, 2002.
2. **Kovacs G.T.A**, Micromachined Transducers, *WCB McGraw Hill,* 1998.
3. **Sze S.M**, Semiconductor Sensors, *John Wiley and Sons*, 1994.
4. **Mahalik N.P**, MEMS, *Tata McGraw Hill,* 2007.

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.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓								
CO2		✓	✓	✓					
CO3				✓					
CO4					✓	✓	✓	✓	✓
CO5	✓	✓		✓		✓			

MEMEX0X	SEMICONDUCTOR DEVICES AND MODELLING	L	T	P
		4	0	0

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 Semiconductors: Atomic picture of Silicon and Germanium – Electric current, free electron density and mobility in Semiconductors - Effect of doping on minority carrier density in Semiconductors – Energy band picture of P and N type Semiconductors – Temperature dependence of conductivity – Degeneracy. Calculation of free electron density and hole density in a Semiconductor – Determination of position of Fermi level for a given Semiconductor – Carrier density expressed in terms of departure of Fermi level from intrinsic Fermi level – Fermi level in N-type and P-type samples as measured from intrinsic Fermi level – Very lightly doped samples – representation of energy band diagram in terms of potential – Equation governing potential distribution in a Semiconductor – Equation governing distribution of hole density and electron density – Continuity equation for Semiconductors – Determination of steady state excess carrier density – Concepts of Quasi Fermi level.

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 – P-N junction behavior in terms of minority carrier stored charge – Calculation of electric field and voltage drop in the bulk.

Quantitative analysis of Bipolar Junction Transistor: Operation of a BJT – Performance parameters – Effect of collector junction voltage on current – Dependence of I_C on V_E and I_E. Uniform Base PNP transistor with Forward biased B-E junction and Reverse biased C-B junction – Calculation of performance parameters – Transit time of minority carriers through base – Effect of floating collector on transistor V - I characteristics – Effect of floating emitter junction characteristics – Collector current with base floating – Temperature effects in Transistors – Effect of device geometry on the transistor performance – Ebermoll's equation.

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:

1. **M.K. Achuthan and K. N. Bhat**, Fundamentals of Semiconductor devices, *Tata McGraw Hill*, New Delhi, 2007.
2. **Ben G Streetman**, Solid State Electronics, *Prentice Hall*, 1999.
3. **S.M.Sze**, Modern Semiconductor Devices Physics, *John Wiley and Sons*, 1998.

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.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓	✓						
CO2	✓	✓	✓						
CO3	✓	✓	✓						
CO4	✓	✓	✓						
CO5	✓	✓	✓						✓

MEMEX0X	POLYSILICON TECHNOLOGY	L	T	P
		4	0	0

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 Deposition : Deposition Process – LPCVD process for polysilicon deposition – Grain size – Grain orientation – physical properties of polysilicon – Influence of deposition condition on the polysilicon structure – recrystallization technique – Dopant diffusion and segregation in polysilicon – Oxidation of polysilicon films.

Electrical Properties : Undoped polysilicon – Moderately doped polysilicon – Carrier trapping at grain boundaries – Grain boundary trap density – Potential barrier – Carrier Transport – Effective mobility – Passivation in polysilicon – Different passivation techniques.

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: Comparison 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:

1. **Ted Kamins**, Polycrystalline Silicon for IC Applications, *Kluwer academic*
2. *Publishers*, Second Edition, 1998.
3. **Sze**. **S.M.** Semiconductor Sensors, *John Wiley and Sons*, 1994.
4. **Sorab. K.Ghandhi**, VLSI Fabrication Principles, Wiley Inter Science Publication, New York, 1994.
5. **Sami Franssila**, Introduction to Microfabrication, John Wiley and Sons, 2004.

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.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓							
CO2							✓	✓	✓
CO3							✓	✓	✓
CO4			✓				✓	✓	✓
CO5			✓				✓	✓	✓

MEMEX0X	MICROFLUIDICS AND BIO MEMS	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To impart knowledge on microfluidics and fluidic sensors.
- To educate on the design of micropumbs.
- To provide an overview on chemical sensors and transducers.
- To introduce the concept of work function based sensors
- To give an overview of the sensors application in the field of biology.

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.

Fluidic channel application: Mixers – Laminating mixers – Plume mixers – Active mixers – Diffusion based extractors – Fluidic amplifiers and logic. **Fluidic Sensors:** Flow sensors – Viscosity sensors – Valves – Passive valves – Active valves – Pneumatic valve action – Thermopneumatic valve actuation – Phase change valve action – Solid expansion valve actuation – Piezoelectric valve actuation – Electrostatic valve actuation – Electromagnetic valve actuation – Bistable valve actuation.

Micropumps: Membrane pumps – Diffuser pumps – Rotary pumps – Electro hydro 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 – Platinide 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.

Biosensors: Resonant biosensors – Optical detection biosensors – Thermal detection biosensors – ISFET biosensors – Other pH based biosensors – Electrochemical detection biosensors – CMOS compatible biosensor process – Enzyme based sensors – Protein based sensors – Immuno sensors – DNA probes and array – DNA amplification.

REFERENCES:

1. **Gregory Kovacs T.A.**, Micromachined Transducers, *WCB McGraw Hill*, 1998.
2. **Marc Madou**, Fundamentals of Microfabrication, The Science of Miniaturization Series, Second Edition, *CRC Press*, 2002.
3. **Albert Folch**, "Introduction to BioMEMS", 1st Edition, CRC Press,
4. **Nam-Trung Nguyen and Steve Wereley**, "Fundamentals and Applications of Microfluidics", 2nd Edition, Artech House.
5. **Terrence Conlisk**, "Essential of Micro and nanofluidics: with applications to biological and chemical sciences", Cambridge University Press, 2012.

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 micropumbs.
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.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓			✓	✓	✓		✓
CO2			✓	✓				✓	✓
CO3	✓		✓					✓	✓
CO4	✓	✓		✓	✓	✓		✓	✓
CO5			✓	✓		✓		✓	✓

MEMEX0X	**VLSI DESIGN**	**L**	**T**	**P**
		4	**0**	**0**

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.

Introduction to VLSI: Digital systems and VLSI - Gate Arrays - Standard Cells - Functional Blocks - CMOS Logic. **Programmable ASICs:** The Antifuse - Static RAM - EPROM and EEPROM Technology - Practical Issues Specifications - PREP Benchmarks - FPGA Economics.

Hardware Description Languages: VHDL: A Counter - A 4-bit Multiplier - Syntax and Semantics of VHDL - Identifiers and Literals Entities and Architectures - Packages and Libraries - Interface

Declarations - Type Declarations - Other Declarations - Sequential Statements – Operators – Arithmetic Concurrent Statements – Execution - Configurations and Specifications - An Engine Controller.

Simulation: Types of Simulation - The Comparator/MUX Example - Logic Systems - How Logic Simulation Works - Cell Models - Delay Models - Static Timing Analysis - Formal Verification - Switch-Level Simulation – Transistor Level Simulation - Summary

Logic Synthesis: Logic-Synthesis - A Logic-Synthesis Example - A Comparator/MUX - Inside a Logic Synthesizer - VHDL and Logic Synthesis - Finite-State Machine Synthesis - Memory Synthesis - The Multiplier - The Engine Controller - Performance-Driven Synthesis - Optimization of the Viterbi Decoder.

Tests: Design for Testability - Test Program Development - Prototype Evaluation **ASIC Construction:** Interconnects and Routing. Floorplanning - Placement - Physical Design Flow - Information Formats.

REFERENCES:

1. **M. John and S. Smith**, Application-Specific Integrated Circuits, *Addison-Wesley*,1997.
2. **Jan M. Rabaey**, **Anantha Chandrakasan and Borivoje Nikolic**, Digital Integrated Circuits – A Design Perspective, *Prentice Hall*, 2002.
3. **Wayne Wolf**, Modern VLSI Design - System-on-Chip Design, *Prentice Hall*, 2002.
4. **Neil H. E. Weste, Kamran Eshraghian, and Micheal John Sebastian**, Principles of CMOS VLSI Design - A Systems Perspective, *Addison Wesley*, 2001.
5. **J. Smith**, HDL Chip Design: A Practical Guide for Designing, Synthesizing & Simulating ASICs and FPGAs using VHDL or Verilog, *Donne Publishing*, 1996.

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.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓			✓					✓
CO2	✓	✓		✓	✓		✓		✓
CO3	✓	✓			✓		✓	✓	✓
CO4			✓		✓	✓	✓		✓
CO5			✓	✓			✓	✓	✓

MEMEX0X	DIGITAL INTEGRATED CIRCUIT DESIGN	L	T	P
		4	0	0

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.

Introduction: Design of static CMOS, nMOS and BiCMOS inverters - . Calculation of noise margins, power dissipation and gate delays - **Review of Logic Design Fundamentals:** Combinational Logic Design - Logic Simplification and Synthesis - Sequential Logic Design - Finite State Machine Design and Implementation

Design of Combinational Circuits: Static CMOS Design - Dynamic CMOS Design - Power Consumption in CMOS gates - Design of Sequential Circuits: Static Sequential Circuits - Dynamic Sequential Circuits.

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

Rapid Prototyping and Implementation of Digital Systems: Field Programmable Gate Arrays (FPGA), Complex Programmable Logic Devices (CPLD) - Logic Synthesis for FPGA and CPLD - Testing and Design for Testability (DFT): Boundary-Scan Test - Faults and Fault Simulation - Automatic Test-Pattern Generation - Scan Test and Built-in Self-test.

REFERENCES:

1. **Rabaey. J**. M, Digital Integrated Circuits - A Design Perspective, Second Edition Prentice- Hall, 2002.
2. **Weste. N and Eshraghian. K**, Principles of CMOS VLSI Design - A Systems Perspective, Prentice-Hall, 1993.
3. **Roth Jr. C. H**, Digital Systems Design Using VHDL, PWS Publishing Com., 1998.
4. **Michael J. S. Smith**, Application-Specific Integrated Circuits, Addison-Wesley, 1997.

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.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓	✓				✓	✓	✓
CO2			✓				✓		✓
CO3					✓	✓	✓	✓	✓
CO4					✓	✓	✓	✓	✓
CO5				✓	✓	✓	✓	✓	✓

MEMEX0X	ADVANCED VLSI SYSTEM DESIGN	L	T	P
		4	0	0

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.

Introduction: Combinational Logic Functions - Static Complementary Gates - Switch Logic. Alternative Gate Circuits - Low Power Gates - Delay Through Resistive Interconnect - Delay Through Inductive Interconnect.

Subsystem Design Principles: Combinational Shifters - Adders - ALUs - Multipliers. High Density Memory - Field Programmable Gate Arrays - Programmable Logic Arrays.

Architecture Design: Introduction - Hardware Description Languages – Register Transfer Design - High-Level Synthesis - Architectures for Low Power - Systems-on-Chips and Embedded CPUs - Architecture Testing.

Chip Design: Introduction - Design Methodologies - Kitchen Timer Chip - Microprocessor Data Path.

CAD Systems and Algorithms: Introduction to CAD Systems - Switch Level Simulation - Layout Synthesis - Layout Analysis - Timing Analysis and Optimization - Logic Synthesis - Test Generation - Sequential Machine Optimizations - Scheduling and Binding - Hardware/Software Co-Design.

REFERENCES:

1. **W. Wolf**, Modern VLSI Design: System-on-Chip Design (Third Edition), *Prentice Hall*, 2002.
2. **Neil H. E. Weste, Kamran Eshraghian, and Micheal John Sebastian**, Principles of CMOS VLSI Design - A Systems Perspective, *Addison Wesley*, 2001.

3. **J. P. Uyemura**, Circuit Design for CMOS VLSI, *Kluwer Academic Publishers*, 1992.
4. **Kerry Bernstein et al.**, High Speed CMOS Design Styles, *Kluwer Academic Publishers*, 1998.

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.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓			✓					✓
CO2	✓	✓		✓	✓		✓		✓
CO3	✓	✓			✓		✓	✓	✓
CO4			✓		✓	✓		✓	✓
CO5			✓	✓			✓	✓	✓

MEMCX0X	FUNDAMENTALS OF IC PACKAGING, ASSEMBLY AND TEST	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To know the importance on Integrated Circuit Packaging.
- To impartthe 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.

Overview of IC Packaging Technology: IC Packaging Roadmap - Technology Driving Forces - Rent's Rule - Hermetic Vs Non-hermetic Packages - Multidiscipline Issues.

Manufacturing Considerations: Die Attach Technology - Die Interconnect Technology - Die Coating - Plastic Package Manufacturing Process - Ceramic Package Manufacturing Process - Metal Can Package Manufacturing Process - Multichip Module - Environmental Control: ESD & Clean room Classification - Quality and Reliability Issues.

Design Considerations: Electrical: Reflection Noise - Crosstalk Noise - Switching Noise Signal Attenuation and Dispersion - Thermal: Thermal Resistance - Heat Flow Mechanisms - Mechanical: Coefficient of Thermal Expansion (CTE) - Thermal Stress and Strain Distribution Management.

Electrical Test: Electrical Performance Testing - Electrical Test Methods - Electrical Analysis.

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:
1. **J. H. Lau, W. Nakayama, J. Prince and C. P. Wong**, Electronic Packaging: Design, Materials, Process, and Reliability, *McGraw Hill*, 1998
2. **G. D. Giacomo**, Reliability of Electronic Packages and Semiconductor Devices, *McGraw - Hill*, 1996.
3. **J. C Whitaker**, The Electronics Handbook, *CRC Press*, 1996.
4. **Tummala, R.R. and Rymaszewski, E.**Microelectronics Packaging Handbook. Van Nostrand Reinhold, New York, 1989.

COURSE OUTCOMES:

Upon completing the course, the student should have

1. Understood the importance and issues of Integrated Circuit Packaging.
2. Acquired the expertisein the manufacturing of variousIntegrated Circuit Packages.
3. Understood the designconsiderations 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.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓							
CO2		✓	✓			✓			
CO3				✓					
CO4					✓	✓	✓		
CO5						✓		✓	

MEMEX0X	MIXED SIGNAL IC DESIGN	L	T	P
		4	0	0

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.

Digital Circuit Design : The MOSFET Switch - Bidirectional Switches - A Clocked Comparator - Common-Mode Noise Elimination - Delay Elements - An Adder. Analog Circuit Design : Biasing - Selecting the Excess Gate Voltage - Selecting the Channel Length - Small-Signal Transconductance - MOSFET Transition Frequency (f_T) - The Beta Multiplier Self-Biased Reference -Op-Amp Design - Output Swing - Slew-rate Concerns - Differential Output Op-Amp.

Integrator Building Blocks : Lowpass Filters - Active-RC Integrators - Effects of Finite Op-Amp Gain Bandwidth Product - Active-RC SNR - MOSFET-C Integrators: use of an Active Circuit (an Op-Amp) - gm-C (Transconductor-C) integrators Common - Mode Feedback Considerations - A High-Frequency Transconductor - Discrete-Time Integrators: An Important Note - Exact Frequency Response of a First-Order Discrete- Time Digital (or Ideal SC) Filter

Filtering Topologies: The Bilinear Transfer Function – Active-RC Implementation – Transconductor-C Implementation – Switched-Capacitor Implementation – Digital Filter Implementation – The Canonic Form (or Standard Form) of a Digital Filter – The Biquadratic Transfer Function : Active-RC Implementation - Switched-Capacitor Implementation - High Q - Q Peaking and Instability - Transconductor-C Implementation - The Digital Biquad Filters using Noise-Shaping - Removing Modulation Noise - Implementing the Multipliers.

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:

1. **Jacob Baker. R**, CMOS Mixed Signal Circuits Design, Wesley-IEEE, 2002.
2. **Gregorian. R and Ternes**, Analog MOS Integrated Circuits for Signal Processing, *Jossey Bass*, 1986.
3. **Gregorian. R**, Introduction to CMOS OP-AMPs and Comparators, *John-Wiley*, 1999.
4. **Johns. D and Martin. K**, Analog Integrated Circuit Design, John-Wiley, 1997.
5. **Razavi. B**, Monolithic Phase-Locked Loops and Clock Recovery Circuits: Theory and Design, IEEE Press, 1996.

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, andKeep up-to-date with future technological development in the field.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓							
CO2		✓	✓			✓			
CO3				✓					
CO4					✓	✓	✓		
CO5						✓		✓	

MEMEX0X	DIGITAL SYSTEM DESIGN WITH HDL (VERILOG)	L	T	P
		4	0	0

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.

Introduction: Introduction to HDL - HDL and Programming Language Comparison- Brief tutorial on Verilog Simulators- Lexical Conventions and Data Types – Value set- nets- registers- vectors- integer, real and time register data types- arrays- memories- parameters – strings- system tasks and compiler directives- modules and ports: list of ports- port declaration- port connection rules- inputs and outputs.

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 assignment delays- implicit continuous assignment delay- expression, operators and operands - Behavior Modelling: Structured Procedures –Procedural Assignments – Timing Controls – Conditional Statements – Multiway Branching – loops – Sequential and Parallel Blocks - Tasks and functions.

Timing and Delay: Types of Delay Models – Path Delay Modelling – Timing Checks – Delay Back Annotation – User Defined Primitives (UDP): UDP Basics – Combinational UDPs – Sequential UDPs.

Simulation: Hierarchical structures - Using External libraries - Timescale and Delay scaling- Timing Checks - Delay Annotation.

Synthesis using Verilog HDL: Verilog HDL Synthesis – Synthesis Design Flow – Verification of Gate Level Netlist – Examples of Sequential Circuit Synthesis.

REFERENCES:

1. **Samir Palnitkar,** Verilog HDL, *Prentice Hall Publications*, Second Edition, 2003.
2. **Bhaskar J**, Verilog HDL Synthesis, *BS Publications*, First Edition, 2001.
3. **S. Brown and Z. Vranesic**, Fundamentals of Digital Logic with VHDL Design', Third edition, McGraw Hill, 2009.
4. **Roth and John,** Digital Systems Design Using VHDL, 2nd Edition, CL publication, 2008.
5. **David R. Smith, Paul Franzon,** Verilog Styles for Synthesis of Digital Systems, Prentice Hall, 2000.

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.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓	✓			✓			✓
CO2	✓					✓		✓	✓
CO3	✓					✓	✓	✓	✓
CO4						✓		✓	✓
CO5	✓	✓	✓	✓	✓	✓	✓	✓	✓

MEMEX0X	OPTOELECTRONIC MATERIALS AND DEVICES	L	T	P
		4	0	0

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

Electronic properties of semiconductor materials for optoelectronic devices: Theory and electrical characteristics of semiconductor materials for optoelectronic devices.**Optical properties of selected semiconductor materials:** Optical characteristics of some semiconductor materials - Photonic bandgap materials.

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:

1. Bhattacharya P, Semiconductor Optoelectronic Devices, *Prentice Hall,* 1998.
2. Piprek J, Introduction to Physics and Simulation of Semiconductor Optoelectronic evices, *Academic Press Incorporated*, 2003.
3. Fukuda M, Optical Semiconductor Devices, *Wiley John and Sons Incorporated*, 1998.
4. Singh J, Semiconductor Optoelectronics: Physics and Technology, *McGraw- Hill* ,1995.
5. Chuang S.L, Physics of Optoelectronic Devices, *Wiley- Interscience*, 1995.

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.

MEMEX0X	MEMS DESIGN AND FABRICATION	L	T	P
		4	0	0

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.

Introduction to micro machined devices: Miniaturization-Microsystem verses MEMS- Micro fabrication- Smart Materials, Structures and System- Integrated Microsystem Micromechanical Structure, Micro sensors, Micro actuator – Introduction to Scaling – Scaling in Geometry-Scaling in Rigid- body dynamics: Scaling in Dynamic Forces - the Trimmer Force Scaling Vector – Scaling in electrostatic forces – scaling in electricity

Micromachining technologies: Silicon as a Material for Micromachining: Crystal Structure of Silicon-Silicon Wafer Preparation- Thin Film Deposition: Evaporation-Sputtering-Chemical Vapour Deposition-Epitaxial Growth of Silicon- Thermal Oxidation for Silicon Dioxide-Lithography: Photolithography – Lift-Off Technique – Etching: Isotropic Etching-Anisotropic Etching-Etch Stops-Dry Etching-Silicon Micromachining – Specialized Materials for Microsystem: Polymers-Ceramic Materials- Advanced Processes for Micro Fabrication-Wafer Bonding Techniques-Special Micro Fabrication Techniques.

Modeling of solids in microsystem: The Simplest Deformable Element: A Bar- Transversely Deformable Element: A Beam –Energy Methods for Elastic Bodies – Examples and Problems- Concepts of spring constant and Estimation of spring constant for simple cantilever beam, fixed-fixed beam microstructures-In-Plane Stresses

Micro Sensors: Concepts of Piezoresistivityand Piezoelectricity- Fabrication Processes, Principle of Operation and Design of Silicon Piezo Resistive Accelerometer, Capacitive Accelerometer, Folded Beam Comb Drive Capacitive Accelerometer,Piezo Electric Accelerometer – Fabrication Processes, Principle of Operation and Design of Silicon Capacitive Pressure Sensor, Silicon Piezo Resistive Pressure Sensor, Piezo Electric Pressure Sensor - Overload Protection in Pressure Sensors- Principle of operations and Fabrication Process of Conductometric Gas Sensors, Portable Blood Analyzers and Piezoelectric Ink Jet Printers. MEMS Actuators and their applications: Actuation mechanisms – Electrostatic actuation – Electrostatic cantilever actuators – Torsional electrostatic actuators – Electrostatic comb drives – Feedback stabilization of electrostatic actuators - Electrostatic rotary micro motors - Electrostatic linear micro motors – Electrostatic micro grippers – Electrostatic relays and switches - Thermal actuation – Thermal expansion of solids – Thermal array actuators –Piezoelectric actuation – Cantilever resonators. RF MEMS switches – Pull in and Pull out voltage analysis.

Integration of micro and smart systems: CMOS FirstApproach -MEMS FirstApproach -Other Approaches of integration- Microsystem Packaging: Objectives of Packaging, Special Issues in Microsystem Packaging, types of microsystem packages, Packaging Technologies, Reliability and key Failure Mechanisms – case studies of integrated microsystems: Pressure sensor, Micro machined Accelerometer.

REFERENCES:

1. **G.K.Ananthasuresh, K.JVinoy, S.Gopalakrishnan, K.N.Bhat, V.K.Aatre**, Micro and Smart Systems, Wiley India, First Edition,2010.
2. **Tai-Ran-Hsu**, MEMS & Microsystems Design and Manufacture, TATA McGraw-Hill, New Delhi, 2002.
3. **Chang Liu**, Foundations of MEMS, (ILLINOIS ECE Series), Pearson Education International, 2006.
4. **Stephen D. Senturia**, Micro system Design, Springer International Edition, 2001.
5. **Gregory TA Kovacs**, Micro machined Transducers Source Book, WCB McGraw Hill, Singapore, 1998.

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. Expertise the knowledge in design of micro sensors and actuators fabrication.
4. Develop various packaging techniques in the design of MEMS.