ANNAMALAI UNIVERSITY

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRONICS AND INSTRUMENTATION ENGINEERING

M.E. MICROELECTRONICS AND MEMS

(Choice Based Credit System)

(Two-Year Full-Time & Three-Year Part-Time)

REGULATION AND SYLLABUS

(2019-2020 Onwards)

1. Conditions for Admission

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

2. Branches of Study in M.E./M.Tech.

Department	Programme (Full-Time & Part-Time)	Eligible B.E./B.Tech. Programme
Electronics & Instrumentation Engineering	Micro Electronics and MEMS	B.E. / B.Tech – B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and Electornics Engg, Electronics and communication Engg, Control and Instrumentation Engg, Instrumentation Engg, Bio Medical Engg, Mechatronics, Telecommunication Engg

3. Courses of study

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

4. Choice Based Credit System (CBCS)

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

5. Assignment of Credits for Courses

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

6. Duration of the programme

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

7. Registration for courses

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

8. Electives

8.1 Program Electives

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

8.2 Open Electives

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

8.3 MOOC (SWAYAM) Courses

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

8.4 Value added courses (Inter Faculty Electives)

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

9. Industrial Project

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

10. Assessment

10.1 Theory Courses

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

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

10.2 Practical Courses

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

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

10.3 Thesis work

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

10.4 Seminar / Industrial Training

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

11. Student Counselors (Mentors)

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

12. Class Committee

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

- Teachers of the individual courses.
- A Thesis coordinator (for Thesis Phase I and II) shall be appointed by the Head of the Department from among the Thesis supervisors.
- A thesis review committee chairman shall be appointed by the Head of the Department

- One Professor or Associate Professor, preferably not teaching the concerned class, appointed as Chairman by the Head of the Department.
- The Head of the Department may opt to be a member or the Chairman.
- All counselors of the class and the Head of the Department (if not already a member) or any staff member nominated by the Head of the Department may opt to be special invitees.

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

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

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

13. Temporary Break Of Study

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

14. Substitute Assessments

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

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

15. Attendance Requirements

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

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

16. Passing and declaration of Examination Results

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

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

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

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

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

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

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

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

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

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

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

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

17. Awarding Degree

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

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

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

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

18. Ranking of Candidates

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

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

19. Transitory Regulations

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

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

M.E. MICROELECTRONICS AND MEMS

VISION

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

MISSION

- To establish state of art facilities related to diverse dimension in the field of Instrumentation Engineering, Biomedical Engineering and Microelectronics and MEMS.
- To foster higher quality of education with equivocal focus in theory and practical areas of Electronics, Control and Instrumentation Engineering, Biomedical Engineering and Microelectronics and MEMS.

- To ensure that the dissemination of knowledge reaches the stakeholders and forge the opening of a fresh flair of human resources.
- To create opportunities for advancements in different facets of this discipline and offer avenues to reach the citadels of one's career.

PROGRAMME EDUCATIONAL OBJECTIVES

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

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

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

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

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

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

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

PROGRAMME OUTCOMES

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

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

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

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

PO4: Understand the basic concepts of MEMS technology**,** an interdisciplinary field related to technologies, used to fabricate nano to micro scale devices and system-on-a-chip that embed electrical, mechanical, chemical, and hybrid mechanisms to realize devices and systems for a broad array of applications such as physical sensors, biomedical systems, and complex multifunctional nano-micro systems.

PO5: Introduce students to the techniques of micro and nano-manufacturing, design and multiphysical simulation tools for the analysis of micro and 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.

Mapping PO with PEO									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
PEO1	✓	✓	✓					✓	
PEO2				✓	✓	✓	✓		
PEO3						✓			
PEO4			✓					✓	
PEO5	✓	✓	✓	✓					
PEO6								✓	✓
PEO7				✓					✓

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

SEMESTER I										
Sl. No.	**Course Code**	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Tota l**	**Credits**
1	19EIMMPC11	PC	Semiconductor Devices and Modelling	3	-	-	25	75	100	3
2	19EIMMPC12	PC	VLSI Fabrication Techniques	3	-	-	25	75	100	3
3	19EIMMPE13	PE	Professional Elective-I	3	-	-	25	75	100	3
4	19EIMMPE14	PE	Professional Elective-II	3	-	-	25	75	100	3
5	19EIMMMC15	MC	Research Methodology and IPR	2	-	-	25	75	100	2
6	19EIMMCP16	CP	Semiconductor Devices Simulation Laboratory	-	-	3	40	60	100	2
7	19EIMMCP17	CP	VLSI Fabrication Laboratory	-	-	3	40	60	100	2
8	19EIMMAC18	AC	Audit Course-I	2	-	-	-	-	-	0
		Total					**205**	**495**	**700**	**18**

SEMESTER II										
Sl. No.	**Course Code**	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**
1	19EIMMPC21	PC	MEMS Technology	3	-	-	25	75	100	3
2	19EIMMPC22	PC	MOS Devices and Modelling	3	-	-	25	75	100	3
3	19EIMMPE23	PE	Professional Elective-III	3	-	-	25	75	100	3
4	19EIMMPE24	PE	Professional Elective-IV	3	-	-	25	75	100	3
5	19EIMMOE25	OE	Open Elective-I (Inter Faculty)	2	-	-	25	75	100	3
6	19EIMMCP26	CP	MEMS Simulation Laboratory	-	-	3	40	60	100	2
7	19EIMMTS27	TS	Industrial Training / Seminar		Tr 2	S 2	40	60	100	2
8	19EIMMAC28	AC	Audit Course-II	2	-	-	-	-	-	0
		Total					**205**	**495**	**700**	**19**

SEMESTER III										
Sl. No.	**Course Code**	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**
1	19EIMMPE31	PE	Professional Elective-V	3	-	-	25	75	100	3
2	19EIMMOE32	OE	Open Elective-II (inter faculty)	3	-	-	25	75	100	3
3	19EIMMTH33	TH-I	Project work & Viva-voce Phase-I	-	Pr 16	S 4	40	60	100	10
		Total					**90**	**210**	**300**	**16**

SEMESTER IV										
Sl. No.	**Course Code**	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**
1	19EIMMTH41	TH-II	Project work & Viva-voce Phase-II	-	Pr 26	S 6	40	60	100	15
		Total					**40**	**60**	**100**	**15**

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

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

PC	Programme Core	CP	Core Practical	AC	Audit Course
PE	Professional Elective	TS	Industrial Training and Seminar	PV	Project work & Viva-voce
OE	Open Elective	MC	Mandatory Learning Course	EI	Branch code
				RI	M.E Specialization Code

M.E. (MICROELECTRONICS AND MEMS) PART-TIME

COURSES OF STUDY AND SCHEME OF EXAMINATION (REGULATION-2019)

SEMESTER I

Sl. No.	Course Code	Category	Course	L	T	P	CA	FE	Total	Credits
1	19PEIMMPC11	PC	Semiconductor Devices and Modelling	3	-	-	25	75	100	3
2	19PEIMMPC12	PC	VLSI Fabrication Techniques	3	-	-	25	75	100	3
3	19PEIMMMC13	MC	Research Methodology and IPR	2	-	-	25	75	100	2
4	19PEIMMCP14	CP-I	Semiconductor Devices Simulation Laboratory	-	-	3	40	60	100	2
		Total					115	285	400	10

SEMESTER II

Sl. No.	Course Code	Category	Course	L	T	P	CA	FE	Total	Credits
1	19PEIMMPC21	PC	MEMS Technology	3	-	-	25	75	100	3
2	19PEIMMPC22	PC	MOS Devices and Modelling	3	-	-	25	75	100	3
3	19PEIMMOE23	OE	Open Elective-I (From the Dept.)	2	-	-	25	75	100	3
4	19PEIMMCP24	CP-III	MEMS Simulation Laboratory	-	-	3	40	60	100	2
		Total					**115**	**285**	**400**	**11**

SEMESTER III

Sl. No.	Course Code	Category	Course	L	T	P	CA	FE	Total	Credits
1	19PEIMMPE31	PE	Professional Elective-I	3	-	-	25	75	100	3
2	19PEIMMPE32	PE	Professional Elective-II	3	-	-	25	75	100	3
3	19PEIMMCP33	CP-II	VLSI Fabrication Laboratory	-	-	3	40	60	100	2
		Total					**90**	**210**	**300**	**8**

SEMESTER IV

Sl. No.	Course Code	Category	Course	L	T	P	CA	FE	Total	Credits
1	19PEIMMPE41	PE	Professional Elective-III	3	-	-	25	75	100	3
2	19PEIMMPE42	PE	Professional Elective-IV	3	-	-	25	75	100	3
3	19PEIMMTS43	TS	Industrial Training / Seminar		Tr 2	S 2	40	60	100	2
		Total					**90**	**210**	**300**	**8**

SEMESTER V

Sl. No.	Course Code	Category	Course	L	T	P	CA	FE	Total	Credits
1	19PEIMMPE51	PE	Professional Elective-V	3	-	-	25	75	100	3
2	19PEIMMPE52	OE	Open Elective-II (From the Dept.)	3	-	-	25	75	100	3
3	19PEIMMTH53	TH-I	Project work & Viva-voce Phase-I		Tr 2	S 2	40	60	100	10
		Total					**90**	**210**	**300**	**16**

SEMESTER VI											
Sl. No.	Course Code	Category	Course	L	T	P	CA	FE	Total	Credits
					Pr	S				
1	19PEIMMTH61	TH-II	Project work & Viva-voce Phase-II	-	26	6	40	60	100	15
		Total					**40**	**60**	**100**	**15**

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

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

LIST OF OPEN ELECTIVES

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

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

19EIMMPC11	SEMICONDUCTOR DEVICES AND MODELLING	L	T	P	C
		3	0	0	3

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 N-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.

Mapping of COs with POs									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓	✓	✓						
CO2	✓	✓	✓						
CO3	✓	✓	✓						
CO4	✓	✓	✓						
CO5	✓	✓	✓						✓

19EIMMPC12	**VLSI FABRICATION TECHNIQUES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

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.
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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.

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓			✓					✓
CO2	✓	✓		✓					✓
CO3	✓	✓	✓				✓	✓	✓
CO4			✓		✓	✓		✓	✓
CO5			✓	✓			✓	✓	✓

19EIMMMC15	RESEARCH METHODOLOGY AND IPR	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES

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

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

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

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

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

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

REFERENCES

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”, Ranjit Kumar, 2 nd Edition , “Research Methodology: A Step by Step Guide for beginners”
3. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
4. Mayall , “Industrial Design”, McGraw Hill, 1992.
5. Niebel , “Product Design”, McGraw Hill, 1974.
6. Asimov , “Introduction to Design”, Prentice Hall, 1962.
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
8. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008.

COURSE OUTCOMES

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

- Understand research problem formulation.
- Analyze research related information.
- Follow research ethics.

- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

MAPPING OF COs WITH POs											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
CO1	✓	✓	✓					✓			✓
CO2	✓	✓	✓								✓
CO3			✓	✓	✓	✓					✓
CO4				✓	✓			✓			✓
CO5				✓	✓	✓		✓			

19EIMMCP16	**SEMICONDUCTOR DEVICES SIMULATION LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**2**

COURSE OBJECTIVES

- To teach the students the basic concepts of semiconductors with appropriate simulation experiments.
- To make them learn the operation of basic PN junction diode and BJT.
- To make them correlate the results obtained in simulation with the theoretical model.
- To educate the students to develop MATLAB programs for simulating basic electronic devices.

LIST OF EXPERIMENTS

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

COURSE OUTCOMES

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

1. Understand the concepts they have learnt in the semiconductor devices modeling course.
2. Develop programs to simulate semiconductors, PN junction diode and BJT and verify their operation under different conditions.
3. Develop models for semiconductor devices.
4. Develop MATLAB programs for simulating basic electronic devices.
5. Work as a software developer for semiconductor devices simulation.

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓	✓						✓
CO2	✓	✓	✓						✓
CO3	✓	✓	✓						✓
CO4	✓	✓	✓						✓
CO5	✓	✓	✓						✓

19EIMMCP17	VLSI FABRICATION LABORATORY	L	T	P	C
		0	0	3	2

COURSE OBJECTIVES

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

LIST OF EXPERIMENTS

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

COURSE OUTCOMES

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

1. Obtain and analyze I-V characteristics of any electronic component using Semiconductor parametric analyser
2. Observe the I-V characteristics for different pacakaged MEMS devices using Semiconductor parametric analyser.
3. Perform wafer level testing of any Integrated circuits or MEMS structure using probe station and semiconductor parameter analyser.
4. Conduct thin film metal deposition and thin film coating in clean room environment.
5. Work in any semiconductor industry environment.

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓	✓				✓	✓	✓
CO2				✓	✓	✓			✓
CO3	✓	✓	✓	✓	✓				✓
CO4				✓	✓	✓			✓
CO5	✓	✓	✓	✓	✓	✓			✓

19EIMMPC21	MEMS TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

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

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.

Bulk MicroMachining: 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**:

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

Design of Pressure Sensors: Piezoreistive Pressure Sensor: Sensing Pressure, Piezoresistance- Analytic Formulation in Cubic Materials-Longitudinal and Transverse Piezoresistance -Piezoresistive Coefficients of Silicon- Structural Examples- Signal Conditioning and Calibration. **Design of Capacitive Accelerometer**: Fundamentals of Quasi-Static Accelerometers, Position Measurement with Capacitance- Circuits for Capacitance Measurement-Demodulation Methods- Case Study- Specifications- Sensor Design and Modeling-Fabrication and Packaging.

REFERENCES

1. G.K. Ananthasuresh, K.J. Vinoy, S. Gopalakrishnan, K.N. Bhat, V.K. Aatre, Micro and Smart Systems, Wiley India, First Edition, 2010..
2. Chang Liu, Foundations of MEMS, (ILLINOIS ECE Series), Pearson Education International, 2006.
3. Gregory TA Kovacs, Micro machined Transducers Source Book, WCB McGraw Hill, Singapore, 1998.
4. Tai-Ran-Hsu, MEMS & Microsystems Design and Manufacture, TATA McGraw-Hill, New Delhi, 2002.
5. Sorab. K.Ghandhi, VLSI Fabrication Principles, Wiley Inter Science Publication, New York, 1994.
6. M.H.Bao "Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes", Elsevier, Newyork, 2000.

COURSE OUTCOMES

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

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

5. Acquire expertise in the design of sensors for any practical applications.

Mapping of COs with POs

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

		L	T	P	C
19EIMMPC22	**MOS DEVICES AND MODELLING**	3	0	0	3

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.

SOLAR CELLOPTOSOI MOSFETS: Advantages of SOI MOSFETs – SOI wafer fabrication techniques – partially depleted SOI MOSFET – Threshold voltage of a partially depleted SOI MOSFETs – kink effect – fully depleted SOI MOSFET – threshold voltage of fully depleted SOI MOSFET.

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

REFERENCES

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

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

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓	✓						✓
CO2	✓	✓	✓						✓
CO3	✓	✓	✓						✓
CO4	✓	✓	✓	✓					✓
CO5	✓	✓	✓				✓	✓	✓

19EIMMCP26	**MEMS SIMULATION LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**2**

COURSE OBJECTIVES

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

LIST OF EXPERIMENTS

1. Study of IntelliSuite Software for the design and fabrication process of MEMS devices.
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.

COURSE OUTCOMES

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

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

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1				✓	✓	✓			✓
CO2				✓	✓	✓			✓
CO3				✓	✓	✓			✓
CO4				✓	✓	✓			✓
CO5				✓	✓	✓			✓

19EIMMTS27 / 19PEIMMTS43	INDUSTRIAL TRAINING / SEMINAR	L	T	P	C
		0	2	2	2

COURSE OBJECTIVES

- To train the students in the field work related to Microelectronics and MEMS to have a practical knowledge in carrying out Microelectronics and MEMS field related works.
- To train and develop skills in solving problems during execution of certain works related to Microelectronics and MEMS.

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

COURSE OUTCOMES

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

19EIMMTH33 / 19PEIMMTH53	PROJECT WORK AND VIVA-VOCE PHASE – I	L	T	P	C
		0	16	4	10

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.

MAPPING OF COs WITH POs									
COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓		✓					✓	✓
CO2	✓			✓	✓				

19EIMMTH41 / 19PEIMMTH61	PROJECT WORK AND VIVA-VOCE PHASE – II	L	T	P	C
		0	24	6	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.

MAPPING OF COs WITH POs									
COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓		✓					✓	✓
CO2	✓			✓	✓				

PE - PROFESSIONAL ELECTIVES

19EIMMPEXX	RF MEMS	L	T	P	C
		3	0	0	3

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.

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1				✓	✓	✓			✓
CO2				✓	✓	✓			✓
CO3				✓	✓	✓			✓
CO4				✓	✓	✓			✓
CO5				✓	✓	✓			✓

19EIMMPEXX	SEMICONDUCTOR POWER DEVICES AND MODELLING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

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

Power Diodes: Breakdown voltage – Avalanche Breakdown – Breakdown voltage in an abrupt junction diode – Punch through diode – Linearly graded junction – Diffused junction diode – Junction termination – Planar diffused termination – Cylindrical termination – Spherical junction – Floating field rings – Multiple floating rings – Beveled edge termination – Positively beveled junction – Negatively beveled junction – Comparison of termination.

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

Power Field Controlled Diodes: Basic structure and characteristics – Forward conduction – Dynamic characteristics – Turn-on analysis – Reverse recovery – Gate turn-off – Frequency response – Gate turn off time – Forward conducting characteristics – High temperature response – Reverse blocking capability – Forward blocking capability – Gating methods.

Power MOSFETs: Basic Structure and operation – Basic device characteristics – Device analysis – Doping profile – Cell spacing – V groove corner – Forward conduction characteristics – Threshold voltage – Channel conductance – ON resistance – Frequency response – Input Capacitance – Switching performance – dv/dt capability – Control of switching speed – DMOS structure and VMOS structure technologies.

IGBT: Basic structure and operation – Device analysis – Reverse blocking capability – Forward blocking capability – IGBT modelling – Frequency response – High temperature Performance.

REFERENCES

1. Jayanth Baliga, Modern Power Devices, *PWS Publications Co.*, 1995.
2. S.K. Ghandhi, Semiconductor Power Devices, *John Wiley Publications*, 1977.
3. M.K. Achuthan and K. N. Bhat, Fundamentals of Semiconductor devices, *Tata McGraw Hill*, New Delhi, 2007

COURSE OUTCOMES

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

1. Understand the function and application of power diodes.
2. Explain the operation of Power JFET quantitatively and qualitatively.
3. Describe the device operation of power field controlled diodes quantitatively and model its characteristics from basic principles.
4. Understand the structure and chracteristics operation of the power MOSFET.
5. Understand the basic structure and modelling of IGBT.

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓	✓						✓
CO2	✓	✓	✓						✓
CO3	✓	✓	✓						✓
CO4	✓	✓	✓						✓
CO5	✓	✓	✓						✓

19EIMMPEXX	FINITE ELEMENT ANALYSIS FOR MEMS	L	T	P	C
		3	0	0	3

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.

REFERENCES

1. Robert D. Cook, Finite Element Modeling for Stress Analysis, *John Wiley and Sons*, 1995.
2. Vince Admas and Abraham Askenazi, Building Better Products with Finite Element Analysis, *On Word Press*, 1998.
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.

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1				✓	✓	✓			✓
CO2				✓	✓	✓			✓
CO3				✓	✓	✓			✓
CO4				✓	✓	✓			✓
CO5				✓	✓	✓			✓

19EIMMPEXX	POLYSILICON TECHNOLOGY	L	T	P	C
		3	0	0	3

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: finite elemntComparison 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.

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓	✓						✓
CO2	✓	✓	✓						✓
CO3	✓	✓	✓						✓
CO4	✓	✓	✓						✓
CO5	✓	✓	✓						✓

19EIMMPEXX	MICROFLUIDICS AND BIO MEMS	L	T	P	C
		3	0	0	3

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.

Mapping of COs with POs

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

19EIMMPEXX	VLSI DESIGN	L	T	P	C
		3	0	0	3

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.

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓	✓				✓	✓	✓
CO2	✓	✓	✓				✓	✓	✓
CO3							✓	✓	✓
CO4							✓	✓	✓
CO5							✓	✓	✓

19EIMMPEXX	DIGITAL INTEGRATED CIRCUIT DESIGN	L	T	P	C
		3	0	0	3

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.

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓	✓				✓	✓	✓
CO2			✓				✓		✓
CO3							✓	✓	✓
CO4							✓	✓	✓
CO5	✓	✓	✓				✓	✓	✓

19EIMMPEXX	ADVANCED VLSI SYSTEM DESIGN	L	T	P	C
		3	0	0	3

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.

Mapping of COs with POs

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

19EIMMPEXX	FUNDAMENTALS OF IC PACKAGING, ASSEMBLY AND TEST	L	T	P	C
		3	0	0	3

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 various Integrated Circuit Packages.
3. Understood the design considerations on various physical parameters.

4. The ability to test and analyse the performance characteristics of Integrated Circuit Packages.
5. Acquired the knowledge of various emerging Integrated Circuit Package technologies.

19EIMMPEXX	MIXED SIGNAL IC DESIGN	L	T	P	C
		3	0	0	3

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.

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓							✓
CO2		✓	✓			✓			✓
CO3				✓					✓
CO4					✓	✓	✓		✓
CO5						✓		✓	✓

19EIMMPEXX	DIGITAL SYSTEM DESIGN WITH HDL (VERILOG)	L	T	P	C
		3	0	0	3

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.

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1							✓	✓	✓
CO2							✓	✓	✓
CO3							✓	✓	✓
CO4							✓	✓	✓
CO5							✓	✓	✓

19EIMMPEXX	FUNDAMENTALS OF NANOELECTRONICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To introduce the idea of quantum mechanics which is totally different from classical mechanics
- To impart knowledge of the structure of carbon nanotubes and its properties

- To make the students to understand principles, properties and applications of carbon nanotubes devices
- To study about generation of CNTFETs and its fabrication techniques
- To familiarize the students to model the nano electronic devices

Quantum Mechanics: Principles of quantum mechanics – Wave Particle Duality - The Uncertainty Principle - Schrodinger – Time Dependent / Independent Equation- Electron in free space -The Infinite Potential Well -Extensions of the Wave Theory to Atoms: The One-Electron Atom- Formation of Energy Bands- The Kronig-Penney Model- The k-Space Diagram-The k-Space Diagrams of Si and GaAs.

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

Carbon Nanotube devices :,Carrier Concentration – Electronic properties of Nanotubes – Electron Transport in ballistic conductor – Carbon Nanotube Electronics: Theory of CNT P-N junction - Carbon Nanotube Transistors – density of states - Schottky Barrier – Ohmic Contacts– Schottky Contacts –Subthreshold, Short- Channel Effects.

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

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1				✓	✓	✓			✓
CO2				✓	✓	✓			✓
CO3				✓	✓	✓			✓
CO4				✓	✓	✓			✓
CO5				✓	✓	✓			✓

Modelling of Nano Conductors and Transistors: The New Ohm's Law-The Bottom-Up Approach-Electrons Flow-Ballistic and Diffusive Transport-Diffusion Equation for Ballistic Transport-Conductivity, Drift-electrostatics- smart contacts. Nano transistors-current equation, physics of Ballistic MOSFET – characteristics.

REFERENCES

1. Semiconductor Physics and Devices Basic Principles, Third Edition, Donald A. Neamen, McGraw-Hill,2003.
2. Lessons from Nanoelectronics. A New Perspective on Transport-Supriyo Datta, Purdue University, USA,2012.
3. The Physics of Carbon Nanotube Devices, ISBN: 978-0-8155-1573-9 François Léonard, 2009 by William Andrew.
4. Michael J. O'Connell, "Carbon Nanotubes: Properties and Applications, ISBN: 9780849327483, CRC Press, 2006

COURSE OUTCOMES

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

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

19EIMMPEXX	PHOTOVOLTAIC DEVICES TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

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

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

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

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

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

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

REFERENCES

1. Physics of solar cells from principles to new concepts: Peter Wurfel
2. Photoelectrochemical Solar Cells: Suresh Chandra
3. Solar energy conversion: A. E. Dixon and J. D. Leslie
4. Solar cells: Martin A. Green
5. Solid State electronic Devices: B.G. Streetman
6. Photoelectrochemical solar cell: Suresh Chandra
7. Dye sensitized solar cell: Michael Graetzel (Review Articles)
8. N. S. Sariciftci and A. J. Heeger in Handbook of Organic Conductive Molecules and Polymers Vol. 1, edited by H. S. Nalwa, John Wiley & Sons, 1997
9. Nanostructured and photoelectrochemical systems for solar photon conversion: Mary D.Archer & Arthur. J. Nozik
10. Quantum Dot Solar Cells. Semiconductor Nanocrystals as Light Harvesters: P. V. Kamat(Review Articles)
11. Clean electricity for photovoltaics: Mary D. Archer & Robert Hill

COURSE OUTCOMES

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

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

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓	✓						✓
CO2	✓	✓	✓						✓
CO3	✓	✓	✓						✓
CO4	✓	✓	✓						✓
CO5	✓	✓	✓						✓

19EIMMPEXX	SOLAR CELL DESIGN AND FABRICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To learn the fundamentals of solar energy conversion systems, available solar energy and the local and national needs, photovoltaic and photothermal engineering applications, emerging technologies.
- To understand the interdisciplinary approach for designing stand-alone PV systems, predicting performance with different systems, Implementing design with cost analysis, Gain system engineering expertise related to photovoltaic energy conversion: generation, storage, and grid connection processes for residential and industrial applications,
- Be able to advance the current technology of the solar energy systems for making the process economical, environmentally safe and sustainable. Be able to serve industries or academia involved in sustainable energy engineering.

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

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

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

Solar cell module design and fabrication: Silicon solar cells to Photovoltaic Module (PV) production, Cell fabrication and interconnections, Top and Bottom connections, Manufacturing process, Cell matrix, encapsulation, vacuum lamination, Post-lamination steps, Bifacial modules, Electrical and optical performance of modules, Local shading and hot spot formation, Field performance. Introduction to concentrated Solar Power (CSP) systems, Energy generation and capacity factor, Tracking requirements, Photovoltaic and solar thermal concentrators, concentrator optics, solar collectors for CSP systems. concentrated Photovoltaic (CPV) systems: Principles and Practices, Fresnel lens, tracking systems. CPV modules, and engineering practices for CPV solar plants.

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

REFERENCES

1. Solar Cells: Operating Principles, Technology and System Applications, Martin Green published by the University of New South Wales, 1980 (Required) available at the BU Barnes and Noble book store
2. Solar Engineering of Thermal Processes, Fourth Edition, John A. Duffie and William A.Beckman, John Wiley and Sons. Inc. 2005 (Chapters 1, 2, 3, and 7) Recommended
3. Photovoltaic Science and Engineering Handbook, Second Edition, Antonio Luque and Steven Hegedus, John Wiley and Sons, 2012 An excellent Resource
4. Thin film Solar Cells, Jeff Poortmans and Vladimir Arkhipov (Ed) John Wiley and Sons Ltd. 2006
5. Solar Cell Device Physics, Second Edition, Stephen J. Fonash, Elsevier, Inc., 2010
6. Solar Electricity, Second Edition, Thomas Markvart (Editor), John Wiley and Sons, Ltd., 2000.
7. Concentrating Solar Power Technology, principles, developments and applications, Keith Lovegrove and Wes Stein, Woodhead Publishing series in Energy, Woodhead Publishing, 1518 Walnut Street, Suite 1100, Philadelphia, PA 19102-3406, USA 2012
8. www.pveducation.org

COURSE OUTCOMES

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

1. Gain an understanding of the available solar energy and the current solar energy conversion and utilization processes,

2. Have a working knowledge of semiconductor physics, optical systems, load matching, and storage and grid connections related to photovoltaic engineering,
3. Be able to comprehend the challenges in sustainable energy processes, perform cost analysis, design photovoltaic systems for different applications meeting residential and industrial needs, predict and test performance, and
4. Understand the manufacturing processes involved, environmental challenges that need to be solved, economic aspects, and future potentials of solar energy utilization
5. Evaluate the performance of a PV solar module using various measurement techniques

Mapping of COs with POs									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓	✓	✓	✓					
CO2	✓	✓	✓	✓					✓
CO3	✓	✓	✓	✓					✓
CO4	✓	✓	✓	✓					✓
CO5	✓	✓	✓	✓					✓

		L	T	P	C
19EIMMPEXX	**INTRODUCTION TO NANOMATERIALS**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES

- To impart knowledge of nanomaterials, its properties and structure.
- To give an overview of fabrication techniques involved in nano fabrication process.
- To understand the function of nanoparticles.
- To study the fabrication of nanostructures.

Introduction: Feynmann"s vision on nanoscience & technology, bulk vs nanomaterials, natural and synthetic nanomaterials. Quantum confinement in nanostructures- size dependent physical phenomena in semiconductor and metal nanoparticles. Classification of nanostructures, 0D, 1D and 2D nanostructures. Visualization of nanostructures and techniques related.

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

Size and shape dependence of nanoparticles: Size effect on the morphology of free or supported nanoparticles, Equilibrium shape of macroscopic crystal. Wulff theorem, equilibrium shape of nanometric crystals. Wulff-Kaichew theorem, equilibrium shape of supported nanoparticles. Kinetics of phase transformations, Homogeneous & Heterogeneous nucleation. Controlling nucleation, growth and aggregation in nanoparticle growth, and crystalline Phase Transitions in Nanocrystals.

Fabrication of nanostructures: Bottom-up approaches for nanostructure fabrication:- Self assembly. Top down approaches for nanostructure fabrication- Lithography- Photolithography- Laser lithography and SPM based lithography (AFM & STM) and nanomanipulation.

REFERENCES

1. Nanostructures and Nanomaterials- Synthesis, Properties & applications by Guozhong Cao, Imperial college Press, (2006).
2. Nanomaterials and Nanochemistry by C. Brechignac.P. Houdy M. Lahmani, Springer-Verlag (2007)
3. Materials Science and Engineering-An Introduction 7e, William D. Callister, Wiley (2007).

COURSE OUTCOMES

Upon completing the course, the student will be able to

1. Understand the basic properties of nano materials and their importance in Nanoelectronics.
2. Gain the knowledge of nanomaterials structure.
3. Acquire the knowledge of the fabrication techniques involved in nano fabrication process.
4. Understand the function of nanoparticles.
5. Provide expertise in the fabrication of nanostructures.

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1				✓	✓	✓			✓
CO2				✓	✓	✓			✓
CO3				✓	✓	✓			✓
CO4				✓	✓	✓			✓
CO5				✓	✓	✓			✓

19EIMMPEXX	DESIGN AND SYNTHESIS OF NANOMATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To introduce the basic theories and techniques of various synthesis methods of nano materials
- To study the various lithographic techniques and its applications in nanofabrication
- To understand the biological methods of synthesis.
- To know the various lithographic techiques used in nanomaterial synthesis.

Physical Methods: Introduction- Spontaneous growth, Evaporation condensation growth, fundamentals of evaporation condensation growth. Vapor – Liquid-Solid (VLS) growth, SWCNT and MWCNT growth mechganisms. Physical Vapour deposition techniques (PVD): Sputtering & Evaporation. Atomic layer deposition, Chemical vapour deposition method (CVD), Molecular beam epitaxy(MBE), & Electrospinning. Laser ablation, Laser pyrolysis, Ball Milling.

Chemical Methods: Nanoparticles through homogeneous & heterogenous nucleation in solution:- Co-precipitation method, Hydrothermal/ Solvothermal synthesis, Template based synthesis, Electrochemical synthesis, Sonochemical routes, Sol- gel, Micelles and microemulsions. Self assembly methods and Langmuir Blodgett (LB) method.

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

Lithographic Techniques: Ebeam lithography and SEM based nanolithography. X-ray Lithography, Focused Ion beam lithography, Near field scanning optical microscopy (NSOM). Atomic Force Microscope Lithography - Dip pen lithography. Microcontact printing, nanoimprint.

REFERENCES

1. Nanostructures and Nanomaterials- Synthesis, Properties & applications by Guozhong Cao, Imperial college Press, (2006).World Scientific Publishing Company; 2 edition (2011)
2. An introduction to Electrospinning and Nanofibers by Seeram Ramakrishna, Kazutoshi Fujihara, Wee Eong Tee, Teck Cheng Lim, Zaveri Ma, World Scientific Publishing Ltd. Singapore, (2005).
3. Springer Handbook of Nanotechnology - Bharat Bhusan, Springer-Verlag (2006)
4. Introduction to Nanoscience & Nanotechnology by Gabor L. Hornyak, Harry F. Tibbals, Joydeep Dutta, John J. Moore, CRC Press, Tylor & Francis Group New York, (2009).
5. Introduction to Nanoscale Science & Technology, Di Ventra, Evoy, Heflin, Springer Science (2004).

COURSE OUTCOMES

Upon completing the course the students will be able to,

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

Mapping of COs with POs									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1				✓	✓	✓			✓
CO2				✓	✓	✓			✓
CO3				✓	✓	✓			✓
CO4				✓	✓	✓			✓
CO5				✓	✓	✓			✓

19EIMMPC12	**CHARACTERIZATION TECHNIQUES OF NANOMATERIALS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

- To study the various spectroscopic characterization techniques to investigate the properties of nano materials
- To impart the knowledge to the students regarding various microscopic techniques available

- To teach the characterization techniques to analyse thermal characteristics of nano materials
- To understand the mechanical properties of nanomaterials using different characterization methods
- To study the magnetic and electrochemical properties of nanomaterials using various suitable techniques

Spectroscopic Techniques: X-ray Spectroscopy: Powder XRD, Small angle X-ray diffraction, GIXRD, and Single crystalline X-ray diffraction. X-ray fluorescence spectroscopy (XAFS). X-ray Photoelectron Spectroscopy (XPS), Ultraviolet Photoelectron Spectroscopy (UPS). Vibrational Spectroscopy: Raman and IR spectroscopy. Fourier Transfrom techniques- FT-IR and FT Raman. Electronic Spectroscopy: Absorption and Emission Spectroscopy.

Microscopic Techniques: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM).. Scanning Probe Microscopy: Atomic Force Microscopy, Scanning Tunneling Microscopy (STM), Near field scanning optical microscopy (NSOM). Confocal Laser Scanning Microscopy.

Techniques for Thermal & Mechanical Analysis: Thermal Analysis: TGA, DTG, DTA, DSC - combustion calorimetry- Thermal diffusivity by the laser flash technique- simultaneous techniques including analysis for gaseous products. Mechanical testing- Introduction, tension testing, High strain rate testing of materials, Fracture Toughness testing methods, Hardness testing. Nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions- models for interpretation of nanoindentation load-displacement curves-Nanoindentation data analysis methods-Hardness testing of thin films and coatings- MD simulation of nanoindentation.

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

REFERENCES

1. Characterization of Materials Vol 1 &2, by Elton N. Kaufmann, John Wiley and Sons Publication, (2003), New Jersey.
2. Principles of instrumental analysis, Douglas A Skoog, Donald M West, Saunders College, Philadelphia, Cengage (2014).
3. X-Ray Diffraction Procedures: For Polycrystalline and Amorphous Materials, 2nd Edition - Harold P. Klug, Leroy E. Alexander, Wiley-Blackwell (1974).
4. Transmission Electron Microscopy: A Textbook for Materials Science (4-Vol Set)- David B. Williams and C. Barry Carter, Springer (2005).
5. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM - Ray F. Egerton, Springer (2010).

COURSE OUTCOMES

Upon completing the course, the students will be able to

1. Understand the spectroscopic characterization techniques to investigate the properties of nano materials

2. Get the knowledge regarding various microscopic techniques available
3. Know the characterization techniques to analyse thermal characteristics of nano materials
4. Calculate the mechanical properties of nanomaterials using different characterization methods
5. Measure the magnetic and electrochemical properties of nanomaterials using various suitable techniques

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1				✓	✓	✓			✓
CO2				✓	✓	✓			✓
CO3				✓	✓	✓			✓
CO4				✓	✓	✓			✓
CO5				✓	✓	✓			✓

19EIMMPEXX	NANO FABRICATION TECHNIQUES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE

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

Nanofabrication by Photons: Introduction to Nanotechnology and Nanofabrication-Principle of Optical Projection Lithography-Optical Lithography at Shorter Wavelengths: Deep UV-Extreme UV-X-ray; Optical Lithography at High NA-Optical Lithography at Low k1 Factor: Off-Axis Illumination (OAI)- Phase-Shifting Mask (PSM)- Optical Proximity Correction (OPC)- Photoresists- Design for Manufacturing (DFM)- Double Processing.

Nanofabrication by Charged Beams: Focusing Charged Particle Beam: Charged Particle Optics-Sources-Aberrations-Scattering and Proximity Effect: Electron Scattering-Proximity Effect and Correction-Effect of Secondary Electrons-Low-Energy E-Beam Lithography-Ion Scattering; Resist Materials and Processes: Sensitivity of Resist Materials-Contrast of Resist Materials-Resolution Enhancement Processes;

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

Nanofabrication by Replication: Thermal Press Nanoimprint: Nanoimprint Stamps-Nanoimprint Polymers-Demolding-Alignmen; Room Temperature Nanoimprint-UV-Cured Nanoimprint: Transparent Stamps-UV Curable Polymers-Step-and-Flash Imprint Lithography-Alignment Through Transparent Stamps-Combined Nanoimprint and Photolithography; Soft Lithography: Soft Stamps-Microcontact Printing-Replication by Capillary Force

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

REFERENCES

1. NanofabricationPrinciples, Capabilities and Limits. Zheng Cui ISBN: 978-0-387-75576-2 Springer Science 2008.
2. NanofabricationTechniques and Principles. Stepanova, Maria, Dew, Steven (Eds.) 2008.
3. Recent advancement in nanofabrication Techniques and applications. Bo Cui ISBN: 978-953-307-602-7 IntechOpen 2011.

COURSE OUTCOMES

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

1. Get the knowledge of various fabrication techniques available in the field of Nanotechnology
2. Understand the concept and methods of lithographic techniques available for nanofabrication
3. Get the knowledge of nanofabrication process by charged beams
4. Get basic idea about various scanning probes technology and their application in the field of nanofabrication
5. Understand the concept of Etching and pattern transfer techniques used in nanofabrication

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1				✓	✓	✓			✓
CO2				✓	✓	✓			✓
CO3				✓	✓	✓			✓
CO4				✓	✓	✓			✓
CO5				✓	✓	✓			✓

OE - OPEN ELECTIVES

19EIMMOEXX	OPTOELECTRONIC MATERIALS AND DEVICES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To impart knowledge on Electronic properties of semiconductor materials for optoelectronic devices.
- To educate on basic structure and realization of Optoelectronic Devices and LEDs.
- To provide an overview on semiconductor LASER diodes and their application in optical fibre communication.

- To introduce the concepts and working of photo detectors and optoelectronic modulators

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 devices, *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.

Mapping of COs with POs									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1				✓	✓	✓			✓
CO2				✓	✓	✓			✓
CO3				✓	✓	✓			✓

CO4				✓	✓	✓			✓
CO5				✓	✓	✓			✓

19EIMMOEXX	MEMS DESIGN AND FABRICATION	L	T	P	C
		3	0	0	3

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.J. Vinoy, 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. Design the solid models for microsystems.
4. Expertise the knowledge in design of micro sensors and actuators fabrication.
5. Develop various packaging techniques in the design of MEMS.

Mapping of COs with POs

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

AUDIT COURSES

19EIMMACXX	ENGLISH FOR RESEARCH PAPER WRITING	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

Students will be able to:

- Understand that how to improve your writing skills and level of readability
- Learn about what to write in each section
- Understand the skills needed when writing a Title Ensure the good quality of paper at very first-time submission syllabus.

Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction.

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

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

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

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

REFERENCES

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books) Model Curriculum of Engineering & Technology PG Courses [Volume-I] [41]
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press 3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook. 4. Adrian Wallwork, English.

19EIMMACXX	DISASTER MANAGEMENT	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

Students will be able to:

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

Introduction Disaster

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

Repercussions Of Disasters And Hazards:

Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

Disaster Prone Areas In India

Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics

Disaster Preparedness And Management

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

Risk Assessment

Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.

Disaster Mitigation Meaning

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

REFERENCES

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi. 3. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep &Deep Publication Pvt. Ltd., New Delhi.

19EIMMACXX	VALUE EDUCATION	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

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

Values and self-development –Social values and individual attitude and work ethics, Indian vision of humanism. Moral and non- moral valuation. Standards and principles. Value judgements.

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

Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature, Discipline.

Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking, Free from anger, Dignity of labour, Universal brotherhood and religious tolerance, True friendship, Happiness Vs suffering, love for truth. Aware of self-destructive habits, Association and Cooperation, Doing best for saving nature.

Character and Competence –Holy books vs Blind faith, Self-management and Good health, Science of reincarnation, Equality, Nonviolence,Humility, Role of Women, All religions and same message, Mind your Mind, Self-control, Honesty, Studying .

REFERENCES

1. Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi.

COURSE OUTCOMES

Students will be able to

1. Knowledge of self-development.
2. Learn the importance of Human values
3. Developing the overall personality

		L	T	P	C
19EIMMACXX	**CONSTITUTION OF INDIA**	**2**	**0**	**0**	**0**

COURSE OBJECTIVES

Students will be able to:

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

History of Making of the Indian Constitution

History, Drafting Committee, (Composition & Working)

Philosophy of the Indian Constitution

Preamble, Salient Features

Contours of Constitutional Rights & Duties

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

Organs of Governance

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

Local Administration

District's Administration Head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.

Panchayati Raj: Introduction, PRI: ZilaPachayat, Elected officials and their roles, CEO ZilaPachayat: Position and role. Block level: Organizational Hierarchy (Different departments),

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

Election Commission

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

REFERENCES

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

COURSE OUTCOMES

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

19EIMMACXX	PEDAGOGY STUDIES	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

Students will be able to:

- Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

Introduction and Methodology

Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions. Overview of methodology and Searching.

Thematic overview

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

Evidence on the effectiveness of pedagogical practices

Methodology for the in depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. eachers' attitudes and beliefs and Pedagogic strategies.

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

Research gaps and future directions

Research design, Contexts, Pedagogy Teacher education, Curriculum and assessment, Dissemination and research impact.

REFERENCES

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher Education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary Education Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

COURSE OUTCOMES

Students will be able to understand:

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

19EIMMACXX	STRESS MANAGEMENT BY YOGA	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

1. To achieve overall health of body and mind
2. To overcome stress

Definitions of Eight parts of yog. (Ashtanga)

Yam and Niyam

Do`s and Don't's in life.

i) Ahinsa, satya, astheya, bramhacharya and aparigraha

ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

Asan and Pranayam

i) Various yog poses and their benefits for mind & body

ii) Regularization of breathing techniques and its effects-Types of pranayam

REFERENCES

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

COURSE OUTCOMES

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

19EIMMACXX	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

Neetisatakam-Holistic development of personality

- Verses- 19,20,21,22 (wisdom)
- Verses- 29,31,32 (pride & heroism)
- Verses- 26,28,63,65 (virtue)
- Verses- 52,53,59 (dont's)
- Verses- 71,73,75,78 (do's)

Approach to day to day work and duties

Shrimad BhagwadGeeta : Chapter 2-Verses 41, 47,48,

Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,

Chapter 18-Verses 45, 46, 48.

Statements of basic knowledge.

Shrimad BhagwadGeeta:

Chapter2-Verses 56, 62, 68

Chapter 12 -Verses 13, 14, 15, 16,17, 18

Personality of Role model. Shrimad BhagwadGeeta:

Chapter2-Verses 17, Chapter 3-Verses 36,37,42,

Chapter 4-Verses 18, 38,39

Chapter18 – Verses 37,38,63

REFERENCES

1. "Srimad Bhagavad Gita" by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

COURSE OUTCOMES

Students will be able to:

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

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