HINDUSTAN UNIVERSITY

HINDUSTAN INSTITUTE OF TECHNOLOGY & SCIENCE

(Estd. u/s 3 of the UGC Act, 1956)

Padur, Kancheepuram District - 603 103.

CENTRE FOR CLEAN ENERGY AND NANO CONVERGENCE (CENCON)

Regulations Curriculum and Syllabus 2013

M.Tech. NANO TECHNOLOGY

ACADEMIC REGULATIONS
(M.TECH./ M.B.A. / M.C.A.) (Full - Time / Part - Time)
(Effective 2013-14)

1. Vision, Mission and Objectives

1.1 The Vision of the Institute is "To make every man a success and no man a failure".

In order to progress towards the vision, the Institute has identified itself with a mission to provide every individual with a conducive environment suitable to achieve his / her career goals, with a strong emphasis on personality development, and to offer quality education in all spheres of engineering, technology, applied sciences and management, without compromising on the quality and code of ethics.

1.2 Further, the institute always strives

- To train our students with the latest and the best in the rapidly changing fields of Engineering, Technology, Management, Science & Humanities.
- To develop the students with a global outlook possessing, state of the art skills, capable of taking up challenging responsibilities in the respective fields.
- To mould our students as citizens with moral, ethical and social values so as to fulfill their obligations to the nation and the society.
- To promote research in the field of science, Humanities, Engineering, Technology and allied branches.

1.3 Our aims and objectives are focused on

- Providing world class education in engineering, technology, applied science and management.
- Keeping pace with the ever changing technological scenario to help our students to gain proper direction to emerge as competent professionals fully aware of their commitment to the society and nation.
- To inculcate a flair for research, development and entrepreneurship.

2. Admission

2.1 The admission policy and procedure shall be decided from time to time by the Board of Management (BOM) of the Institute, following guidelines issued by Ministry of Human Resource Development (MHRD), Government of India. The number of seats in each branch of the (M.TECH / M.B.A. / M.C.A.) programme will be decided by BOM as per the directives from Ministry of Human Resource Development (MHRD), Government of India and taking into account the market demands. Some seats for Non Resident Indians and a few seats for foreign nationals shall be made available.

2.2 The selected candidates will be admitted to the (M.TECH / M.B.A. / M.C.A.) programme after he/she fulfills all the admission requirements set by the Institute and after payment of the prescribed fees.

2.3 Candidates for admission to the first semester of the Master's Degree Programme shall be required to have passed an appropriate Degree Examination recognized by Hindustan University.

2.4 In all matters relating to admission to the (M.TECH / M.B.A. / M.C.A.). Programme, the decision of the Institute and its interpretation given by the Chancellor of the Institute shall be final.

2.5 If at any time after admission, it is found that a candidate has not fulfilled any of the requirements stipulated by the Institute, the Institute may revoke the admission of the candidate with information to the Academic Council.

3. Structure of the programme

3.1 The programme of instruction will have the following structure

i) Core courses of Engineering / Technology / Management.

ii) Elective courses for specialization in areas of student's choice

3.2 The minimum durations of the programmes are as given below:

Program	No. of Semesters
M.Tech.(Full-Time)	4
M.Tech.(Part -Time)	6
M.B.A. (Full - Time)	4
M.B.A. (Part - Time)	6
M.C.A.(Full - Time)	6
M.C.A.(Part -Time)	8

Every (M.TECH / M.B.A. / M.C.A.) programme will have a curriculum and syllabi for the courses approved by the Academic Council.

3.3 Each course is normally assigned certain number of credits. The following norms will generally be followed in assigning credits for courses.

- One credit for each lecture hour per week per semester
- One credit for each tutorial hour per week per semester
- One credit for each laboratory practical of three hours per week per semester.
- One credit for 4 weeks of industrial training and
- One credit for 2 hours of project per week per semester.

3.4 For the award of degree, a student has to earn certain minimum total number of credits specified in the curriculum of the relevant branch of study. The curriculum of the different programs shall be so designed that the minimum prescribed credits required for the award of the degree shall be within the limits specified below.

Program	Minimum prescribed credit range
M.Tech. (Full time / Part time)	75 - 85
M.B.A. (Full time / Part time)	85 - 95
M.C.A (Full time / Part time)	115 - 125

3.5 The medium of instruction, examination and the language of the project reports will be English.

4. Faculty Advisor

4.1 To help the students in planning their courses of study and for getting general advice on the academic programme, the concerned Department will assign a certain number of students to a Faculty member who will be called their Faculty Advisor.

5. Class Committee

5.1 A Class Committee consisting of the following will be constituted by the Head of the Department for each class:

(i) A Chairman, who is not teaching the class.

(ii) All subject teachers of the class.

(iii) Two students nominated by the department in consultation with the class.

The Class Committee will meet as often as necessary, but not less than three times during a semester.

The functions of the Class Committee will include:

(i) Addressing problems experienced by students in the classroom and the laboratories.

(ii) Analyzing the performance of the students of the class after each test and finding ways and means of addressing problems, if any.

(iii) During the meetings, the student members shall express the opinions and suggestions of the class students to improve the teaching / learning process.

6. Grading

6.1 A grading system as below will be adhered to.

Range of Marks	Letter Grade	Grade points
95-100	S	10
85 - 94	A	09
75- 84	B	08
65-74	C	07
55-64	D	06
50-54	E	05
< 50	U	00
	I (Incomplete)	–

6.2 GPA & CGPA

GPA is the ratio of the sum of the product of the number of credits C_i of course "i " and the grade points P_i earned for that course taken over all courses "i" registered by the student to the sum of Ci for all "i ". That is,

$$GPA = \frac{\sum_i C_i P_i}{\sum_i C_i}$$

CGPA will be calculated in a similar manner, at any semester, considering all the courses enrolled from first semester onwards.

6.3 For the students with letter grade I in certain subjects, the same will not be included in the computation of GPA and CGPA until after those grades are converted to the regular grades.

6.4 Raw marks will be moderated by a moderation board appointed by the Vice-Chancellor of the University. The final marks will be graded using an absolute grading system. The Constitution and composition of the moderation board will be dealt with separately.

7. Registration and Enrollment

7.1 Except for the first semester, registration and enrollment will be done in the beginning of the semester as per the schedule announced by the University.

7.2 A student will be eligible for enrollment only if he/she satisfies regulation 10 (maximum duration of the programme) and will be permitted to enroll if (i) he/she has cleared all dues in the Institute, Hostel & Library up to the end of the previous semester and (ii) he/she is not

debarred from enrollment by a disciplinary action of the University.

7.3 Students are required to submit registration form duly filled in.

8. Registration requirement

8.1 **(i)** A Full time student shall not register for less than 16 credits or more than 26 credits in any given semester.

8.1 **(ii)** A part time student shall not register for less than 10 credits or more than 20 credits in any given semester.

8.2 If a student finds his/her load heavy in any semester, or for any other valid reason, he/she may withdraw from the courses within three weeks of the commencement of the semester with the written approval of his/her Faculty Advisor and HOD. However the student should ensure that the total number of credits registered for in any semester should enable him/her to earn the minimum number of credits per semester for the completed semesters.

9. Minimum requirement to continue the programme

9.1 For those students who have not earned the minimum required credit prescribed for that particular semester examination, a warning letter to the concerned student and also to his parents regarding the shortage of his credit will be sent by the HOD after the announcement of the results of the university examinations.

10. Maximum duration of the programme

The minimum and maximum period for the completion of various programs are given below.

Program	Min. No. of Semesters	Max. No. of Semesters
M.Tech (Full - time)	4	8
M.Tech (Part - time)	6	10
M.B.A. (Full Time)	4	8
M.B.A. (Part Time)	6	10
M.C.A. (Full - Time)	6	12
M.C.A (Part -Time)	8	14

11. Temporary discontinuation

11.1 A student may be permitted by the Director(academic) to discontinue temporarily from the programme for a semester or a longer period for reasons of ill health or other valid reasons. Normally a student will be permitted to discontinue from the programme only for a maximum duration of two semesters.

12. Discipline

12.1 Every student is required to observe discipline and decorum both inside and outside the campus and not to indulge in any activity which will tend to bring down the prestige of the University.

12.2 Any act of indiscipline of a student reported to the Director (Academic) will be referred to a Discipline Committee so constituted. The Committee will enquire into the charges and decide on suitable punishment if the charges are substantiated. The committee will also authorize the Director(Academic) to recommend to the Vice-Chancellor the implementation of the decision. The student concerned may appeal to the Vice-Chancellor whose decision will be final. The Director (Academic) will report the action taken at the next meeting of the Council.

12.3 Ragging and harassment of women are strictly prohibited in the University campus and hostels.

13. Attendance

13.1 A student whose attendance is less than 75% is not eligible to appear for the end semester examination for that semester. The details of all students who have attendance less than 75% will be announced by the teacher in the class. These details will be sent to the concerned HODs and Director (Academic).

13.2 Those who have less than 75% attendance will be considered for condonation of shortage of attendance. However a condonation of 10% in attendance will be given on medical reasons. Application for condonation recommended by the Faculty Advisor, concerned faculty member and the HOD is to be submitted to the Director (Academic) who, depending on the merits of the case, may permit the student to appear for the end semester examination. A student will be eligible for this concession at most in two semesters during the entire degree programme. Application for medical leave, supported by medical certificate with endorsement by a Registered Medical Officer, should reach the HOD within seven days after returning from leave or, on or before the last instructional day of the semester, whichever is earlier.

13.3 As an incentive to those students who are involved in extra curricular activities such as representing the University in Sports and Games, Cultural Festivals, and Technical Festivals, NCC/ NSS events, a relaxation of up to 10% attendance will be given subject to the condition that these students take prior approval from the officer-in-charge. All such applications should be recommended by the concerned HOD and forwarded to Director (Academic) within seven instructional days after the programme/activity.

14. Assessment Procedure

14.1 The Academic Council will decide from time to time the system of tests and examinations in each subject in each semester.

14.2 For each theory course, the assessment will be done on a continuous basis as follows:

Test / Exam	Weightage	Duration of Test Exam
First Periodical Test*	10%	2 Periods
Second Periodical Test*	10%	2 Periods
Model exam	20%	3 hours
Seminar/ Assignments/Quiz	20%	
End - semester examination	50%	3 Hours

*** Best out of the two tests will be considered.**

14.3 For practical courses, the assessment will be done by the subject teachers as below:

(i) Weekly assignment/Observation note book / lab records - weightage 60%.

(ii) End semester examination of 3 hours duration including viva - weightage 40%

15. Make up Examination/model examination

15.1 Students who miss the end-semester examinations / model examination for valid reasons are eligible for make-up examination /model examination. Those

who miss the end-semester examination / model examination should apply to the Head of the Department concerned within five days after he / she missed examination, giving reasons for absence.

15.2 Permission to appear for make-up examination / model exam will be given under exceptional circumstances such as admission to a hospital due to illness. Students should produce a medical certificate issued by a Registered Medical Practitioner certifying that he/she was admitted to hospital during the period of examination / model exam and the same should be duly endorsed by parent / guardian and also by a medical officer of the University within 5 days.

16. Project evaluation

16.1 For Project work, the assessment will be done on a continuous basis as follows:

Review / Examination	Weightage
First Review	10%
Second Review	20%
Third Review	20%
End semester Examination	50%

For end semester exam, the student will submit a Project Report in a format specified by the Director (Academic). The first three reviews will be conducted by a Committee constituted by the Head of the Department. The end - semester examination will be conducted by a Committee constituted by the Controller of Examinations. This will include an external expert.

17. Declaration of results

17.1 A candidate who secures not less than 50% of total marks prescribed for a course with a minimum of 50% of the marks prescribed for the end semester examination shall be declared to have passed the course and earned the specified credits for the course.

17.2 After the valuation of the answer scripts, the tabulated results are to be scrutinized by the Result Passing Boards of PG programmes constituted by the Vice-Chancellor. The recommendations of the Result Passing Boards will be placed before the Standing Sub Committee of the Academic Council constituted by the Chancellor for scrutiny. The minutes of the Standing Sub Committee along with the results are to be placed before the Vice-Chancellor for approval. After getting the approval of the Vice-Chancellor, the results will be published by the Controller of Examination/ Registrar.

17.3 If a candidate fails to secure a pass in a course due to not satisfying the minimum requirement in the end semester examination, he/she shall register and re-appear for the end semester examination during the following semester. However, the sessional marks secured by the candidate will be retained for all such attempts.

17.4 If a candidate fails to secure a pass in a course due to insufficient sessional marks though meeting the minimum requirements of the end semester examination, wishes to improve on his/ her sessional marks, he/she will have to register for the particular course and

attend the course with permission of the HOD concerned and the Registrar. The sessional and external marks obtained by the candidate in this case will replace the earlier result.

17.5 A candidate can apply for the revaluation of his/her end semester examination answer paper in a theory course within 2 weeks from the declaration of the results, on payment of a prescribed fee through proper application to the Registrar/Controller of Examinations through the Head of the Department. The Registrar/ Controller of Examination will arrange for the revaluation and the results will be intimated to the candidate concerned through the Head of the Department. Revaluation is not permitted for practical courses and for project work.

17.6 The weightage for internal marks in finalizing results and grades shall be waived off after completion of 5 semesters.

18. Grade Card

18.1 After results are declared, grade sheet will be issued to each student, which will contain the following details:

(i) Program and branch for which the student has enrolled.

(ii) Semester of registration.

(iii) List of courses registered during the semester and the grade scored.

(iv) Semester Grade Point Average (GPA)

(v) Cumulative Grade Point Average (CGPA).

19. Class / Division

19.1 Classification is based on CGPA and is as follows:

CGPA $\geq$ 8.0 : **First Class with distinction**

6.5 $\leq$ CGPA < 8.0 : **First Class**

5.0 $\leq$ CGPA < 6.5 : **Second Class.**

19.2 (i) Further, the award of 'First class with distinction' is subject to the candidate becoming eligible for the award of the degree having passed the examination in all the courses in his/her first appearance within the minimum duration of the programme.

(ii) The award of 'First Class' is further subject to the candidate becoming eligible to the award of the degree having passed the examination in all the courses within the below mentioned duration of the programme.

Program	No. of Semesters
M.Tech.(Full-Time)	5
M.Tech.(Part -Time)	7
M.B.A. (Full - Time)	5
M.B.A. (Part - Time)	7
M.C.A.(Full - Time)	7
M.C.A.(Part -Time)	9

(iii) The period of authorized discontinuation of the programme (vide clause 11.1) will not be counted for the purpose of the above classification.

20. Transfer of credits

20.1 Within the broad framework of these regulations, the Academic Council, based on the recommendation of the transfer of credits committee so constituted by the Chancellor may permit students to earn part of the credit requirement in other approved institutions of repute and status in the country or abroad.

21. Eligibility for the award of (M.TECH / M.B.A. / M.C.A.) Degree

21.1 A student will be declared to be eligible for the award of the (M.TECH / M.B.A. / M.C.A.). Degree if he/she has

i) registered and successfully credited all the core courses,

ii) successfully acquired the credits in the different categories as specified in the curriculum corresponding to the discipline (branch) of his/her study within the stipulated time,

iii) has no dues to all sections of the Institute including Hostels, and

iv) has no disciplinary action pending against him/her.

The award of the degree must be recommended by the Academic Council and approved by the Board of Management of the University.

22. Power to modify

22.1 Notwithstanding all that has been stated above, the Academic Council has the right to modify any of the above regulations from time to time subject to approval by the Board of Management.

M.Tech. program in Nanotechnology

(Potential Dual Degree program with Dongguk University, South Korea)

Being a potential thrust area for industrial applications, Hindustan University jointly with Dongguk University, South Korea is offering M.Tech Nanotechnology program to educate and train students from the Science as well as Engineering streams in the fundamentals of Nano science.

The entire curriculum is designed to enable the students to gain the profound insight into the fundamentals of nanotechnology. The students will experience the science behind nano-devices, fabrication nuances of nano-materials and its diverse applications.Individual exposure to Hands on experience with instrumental methods to characterize Nano-materials will be provided. Interactive video conferencing by Global experts, Webinars and Special lectures by Scientists from across the globe will be arranged to educate the students.

The electives are designed with industry oriented focusto enable the student to identify their specific area of interest to tailor their career path.The program culminates with the project work that begins in semester three and is to be completed at the end of semester four.The students will be placed in our various collaborating institutes like Dongguk University, South Korea, Uppsala University, Sweden, KTH, Sweden, Government research organizations, etc. for their final year projects.

Considering the tremendous scope and application of Nanotechnology, career opportunities in the fields of nanoscale science and technology is also intensifying. A professional with the M.Tech (Nanotechnology) can easily find lucrative career opportunities in various sectors like R& D, Industries, Academics.

HINDUSTAN INSTITUTE OF TECHNOLOGY AND SCIENCE
CLEAN ENERGY AND NANOCONVERGENCE CENTRE

M.TECH. NANOTECHNOLOGY

SEMESTER I

Sl. No.	Course Code	Course Title	L	T	P	C	TCH
Theory							
1	PNT 101	Physics and Chemistry of Materials	3	0	0	4	3
2	PNT 102	Introduction to Nanotechnology	3	0	0	4	3
3	PNT 103	Synthesis methodologies of Nanomaterials	3	0	0	4	3
4	PNT 104	Advanced Materials	3	0	0	4	3
5	PNT 105	Nanoelectronics	3	0	0	4	3
6	PNT 106	Handling, Safety and Hazard analysis of Nanomaterials	3	0	0	4	3
Practicals							
6	PNT 111	Materials and electronics Lab	0	0	4	2	4
7		Communication skills seminar	1	0	0	0	2
		TOTAL				**26**	**24**

TOTAL NO OF CREDITS : 26

SEMESTER II

Sl. No.	Course Code	Course Title	L	T	P	C	TCH
Theory							
1	PNT 201	Nanomaterials in Energy generation and storage.	3	0	0	4	3
2	PNT 202	Nanophotonics	3	0	0	4	3
3	PNT 203	Computational science for Nanotechnology	3	0	0	4	3
4	PNT 204	Characterization techniques for Nanomaterials	3	0	0	4	3
5		Elective I	3	0	0	3	3
6		Elective II	3	0	0	3	3
Practicals							
7	PNT 209	Nanomaterial Synthesis and computational Lab	0	0	4	2	4
		TOTAL				**24**	**22**

TOTAL NO OF CREDITS : 24

SEMESTER III

Sl. No.	Course Code	Course Title	L	T	P	C	TCH
Theory							
1		Elective III	3	0	0	3	3
2		Elective IV	3	0	0	3	3
3		Elective V	3	0	0	3	3
Practicals							
5	PNT 308	Analytical techniques - Results and Analysis Lab	0	0	6	2	6
6	PNT 309	Project Phase-I	0	0	12	6	12
7		Seminar	0	0	2	0	2
		TOTAL				**17**	**29**

TOTAL NO OF CREDITS : 17

SEMESTER IV

Sl. No.	Course Code	Course Title	L	T	P	C	TCH
Practicals							
		Project / Viva Voce	0	0	24	12	24
		TOTAL				**12**	**24**

TOTAL NO OF CREDITS : 12

Total No. of Credits for the Course

Semester I	**26**
Semester II	**24**
Semester III	**17**
Semester IV	**12**
Total	**79**

LIST OF ELECTIVES

Sl.No.	Course Code	Course Title
Electives I & II		
1.	PNT 701	Colloid and Interface Science
2.	PNT 702	Solid state Optoelectronic Devices
3.	PNT 703	Nano Biotechnology
4.	PNT 704	Nanocomposites
5.	PNT 705	Micro and Nano electromechanical Systems
6.	PNT 706	Environmental Nanotechnology
Electives III, IV &V		
1.	PNT 707	Micro/Nanofluidics
2.	PNT 708	Carbon nano Structures and functionalization
3.	PNT 709	Nanomaterials for Health Care
4.	PNT710	Nanomaterial Based Sensors and Acutators
5.	PNT 711	Energy Management
6.	PNT 712	Bioinformatics

SEMESTER I

PNT101 PHYSICS AND CHEMISTRY OF MATERIALS

L	T	P	C	TCH
3	0	0	4	3

GOAL

To teach students the basics and fundamentals of materials

OBJECTIVES

The course should enable the students to :

1. Understand the building block of materials.
2. Understand the concepts in different phases of materials
3. Basics of semiconductors
4. Get knowledge on the different properties of materials.
5. Understand the science of polymer materials

OUTCOME

The students will be able to:

1. Develop knowledge on the basics of bonding and structure of atoms.
2. Understand phase equilibrium and phase transformations.
3. Learn the basics of semiconductor materials, different types of semiconductors and its conductivity
4. Explore mechanical, optical and magnetic properties of materials
5. Understand classification of polymers, concepts of molecular mass and its properties.

UNIT I INTRODUCTION TO ATOMS AND CRYSTAL PHYSICS 9

Structure of atoms- Quantum states-Atomic bonding in solids-binding energy-inter atomic spacing - variation in bonding characteristics- Single crystals-polycrystalline- Non crystalline solids-Imperfection in solids -Vacancies- Interstitials- Geometry of dislocation- Schmid´s law- Surface imperfection-Importance of defects- Microscopic techniques- grain size distribution

UNIT II PHASE EQUILIBRIUM AND PHASE TRANSFORMATIONS 9

Solutions and alloys- Phase diagrams- Gibbs phase rule- Single component systems- Eutectic phase diagram - lever rule- Study of properties of phase diagrams- Phase transformation-Nucleation kinetics and growth

UNIT III SEMICONDUCTORS AND THEIR PROPERTIES 9

Band model of semiconductors - carrier concentrations in intrinsic, extrinsic semiconductors -organic semiconductors- Fermi level - variation of conductivity, mobility with temperature -law of mass action-Hall effect - Hall coefficients for intrinsic and extrinsic semiconductors - Hall effect devices

UNIT IV PROPERTIES OF MATERIALS **9**

Mechanical properties- Stress, Strain, Elastic properties- Deformation- elasticity- hardness- Optical properties- Light interaction with solids- Atomic, electronic interaction, non- radiative transition- refraction, reflection, Absorption, Transmission, Insulators, luminescence- Magnetic properties- , paramagnetism - ferromagnetism - domain theory - magnetic hysteresis , Weiss molecular field theory, Heisenberg's theory - magnetic anisotropy - domain walls - Exchange energy - Antiferromagnetism

UNIT V POLYMER MATERIALS **9**

Classification of polymers -Degree of polymerization- Concept of molecular mass- number average - weight average- viscosity average molecular weight -molecular weight distribution in linear polymers -Kinetics of polymerization- Free radical chain polymerization- Cationic polymerizations-Anionic polymerizations- polycondensation polymerization techniques - Bulk, solution, suspension, emulsion polymerization - Mechanical properties of polymers

Total: 45

TEXT BOOKS :

1. C. Kittel, "Introduction to Solid State Physics", Wiley Eastern Ltd., 2005.
2. V. Raghavan, "Materials Science and Engineering: A First Course", Prentice Hall, 2006.
3. V.R.Gowariker, "Polymer science ", New age international Publishers, 1986.

REFERENCE BOOKS:

1. W. D. Callister, "Materials Science and Engineering: An Introduction", John Wiley & Sons, 2007.
2. A.J. Dekker, "Solid State Physics", Macmillan & Co., 2000.
3. Michael Shur, Physics of Semiconductor Devices, Prentice Hall of India, 1995.

PNT 102 INTRODUCTION TO NANOTECHNOLOGY

L	T	P	C	TCH
3	0	0	4	3

GOAL

To understand fundamentals of Nanotechnology and different structures of nanomaterials and their application.

OBJECTIVES

The course should enable the students to :

1. Introduce to new era of technology- Nanotechnology
2. Understand the concepts in interatomic forces between materials
3. Basics of dimensional nano structures
4. Get knowledge on the multi dimensional nanomaterials
5. Know the consequences of the nanoscale materials in different applications

OUTCOME

The students will be able to:

1. Know history and importance of Nanotechnology.
2. Learn forces between materials, particles and it's thermodynamics.
3. Learn the basics of zero dimentional nano particles and its nucleation kinetics
4. Learn different dimensions of nano structures and its fabrication techniques
5. Understand social implications of Nanoscience and its applications.

UNIT I INTRODUCTION **9**

Importance of Nanotechnology- History of Nanotechnology - Properties of Nano materials - Difference between Bulk and Nanomaterial - Molecular building blocks for nanostructure systems - Influence of Nano structure on mechanical - optical, electronic - magnetic and chemical properties.

UNIT II INTER ATOMIC FORCES **9**

Forces between atoms and molecules - Particles and grain boundaries - strong Intermolecular forces - Electrostatic and Vander Waals forces between surfaces - similarities and differences between intermolecular and inter particle forces - covalent and coulomb interactions - interaction polar molecules - Thermodynamics of self assembly.

UNIT III ZERO DIMENSIONAL NANO-STRUCTURES **9**

Nano particles - Nucleation- homogeneous nucleation-growth of nuclei- Metallic Nano particles- heterogeneous nucleation- Fundamentals of heterogeneous nucleation - synthesis of nano particles using micro emulsions and Aerosol.

UNIT IV MULTI DIMENSIONAL NANO-STRUCTURES **9**

Nano wires and Nano rods, Spontaneous growth - Evaporation and condensation growth, vapor-liquid-solid growth - stress induced recrystallization - fundamentals of template based synthesis - 2D and 3D films - Fundamentals of thin film growth - Nano and mesopores - micelles - bilayer - vesicles - grain structure of films and coatings - Amorphous thin films.

UNIT V CONSEQUENCES OF THE NANOSCALE FOR TECHNOLOGY AND SOCIETY **9**

Societal Implications of Nanoscience and Nanotechnology - Knowledge and scientific understanding of nature - Industrial manufacturing - materials and products - Medicine and the human body - Application of Nanotechnology in Agriculture - water - energy materials and clean environment - Space exploration - National security and sustainability.

Total: 45

TEXT BOOKS :

1. T.Pradeep - "Nano: The Essentials" - Tata McGraw Hill, New Delhi, 2007
2. 2. Charles P. Poole, Jr. and Frank J.Owens, " Introduction to Nanotechnology", Wiley, 2003

REFERENCE BOOKS:

1. Chris Binns, "Introduction to Nanoscience and NanoTechnology", John Wiley and Sons.,2010.
2. Horst-Gunter Rubahn, "Basics of Nano Technology", Wiley-VCH Verlag Gmbh,2008.
3. Guozhong Cao - "Nano structures and Nano materials: Synthesis, properties and applications" - Imperial College press.

PNT 103 SYNTHESIS METHODOLOGIES OF NANOMATERIALS

L	T	P	C	TCH
3	0	0	4	3

GOAL

To understand the science behind Nanodevices and fabrication of nanomaterials

OBJECTIVES

The course should enable the students to :

1. Introduce to quantum mechanics
2. Understand the concepts in nucleation and growth
3. Know the synthesis of nanomaterials
4. Get knowledge on the fabrication of nanomaterials.
5. Know the thin film synthesis

OUTCOME

The students will be able to:

1. Know quantum postulates and size dependent phenonmena.
2. Have an idea about growth kinetics of nanoparticles and growth techniques.
3. Learn top down approach of synthesis
4. Learn different bottom up approach for fabrication of nano materials
5. Understand different deposition techniques of thin films

UNIT I INTRODUCTION TO NANOWORLD **9**

Classical Mechanics - Quantum mechanics postulates - advancement- Uncertainty principle- Schrodinger's Time Dependent/ Time Independent wave equations - Importance of Classical and Quantum free electron theory of metals - applications - Particle in a box - tunneling effect-Dimensionality and size dependent phenomenon - Role of size in nanomaterials.

UNIT II NUCLEATION &GROWTH **9**

Nanoparticles through homogeneous nucleation - Growth controlled by diffusion - growth controlled by surface process - influences of reduction reagents - solid state phase segregation kinetically confined synthesis of nanoparticles - template based synthesis. Self-assembly - self assembled monolayers - SAMs - Langmuir - Blodgett films - clusters - colloids - zeolites

UNIT III SYNTHESIS: TOP DOWN APPROACH **9**

Synthesis of bulk nano-structured materials - Lithographic techniques - Importance of lithographic technique - E-beam and ion beam Lithography - Principle and instrumentation - Etching techniques - Wet chemical etching - Dry etching - Ball milling technique - Machining processes - mechanical alloying - micro milling.

UNIT IV SYNTHESIS: BOTTOM UP APPROACH **9**

Sol-gel synthesis - Spin coating -Thin film techniques - Molecular beam epitaxy - Liquid phase epitaxy - Printing technologies - Sputtering technologies - Ion deposition -Ion implantation

UNIT V DEPOSITION TECHNIQUES **9**

Electrodeposition - Cathodic arc deposition - Pulsed laser deposition- Chemical Vapor Deposition - - Metal Organic Chemical Vapor Deposition - Plasma CVD - Photo-enhanced CVD /Physical vapor deposition - Atomic Layer Deposition

Total: 45

REFERENCE BOOKS:

1. Brandsen, Joachain, "Quantum Mechanics", Pearson Education, 2008
2. SV. Gaponenko, "Optical Properties of semiconductor nanocrystals", Cambridge University Press, 1998.
3. W.Goddard, "Handbook of NanoScience, engineering and technology", CRC Press, 2007.
4. G.Cao, "Nanostructures and Nanomaterials: Synthesis, Properties and Applications", Imperial College Press, 2004.
5. Willard, "Instrumental Methods of Analysis", Van Nostrand, 2000.

PNT 104 ADVANCED MATERIALS

L	T	P	C	TCH
3	0	0	4	3

GOAL

This paper familiarizes students with new advanced Materials

OBJECTIVES

The course should enable the students to :

1. Understand solid state materials
2. Learn about carbon nanotubes
3. Know thermoelectric materials
4. Get knowledge on piezoelectric materials
5. Know magnetic fluid materials

OUTCOME

The students will be able to:

1. Know classification of solid and smartmaterials
2. Understand CNT & its types and applications
3. Understand the conceptbehind thermoelectric materials
4. Learn importance of PZT materials and its applications
5. Understand different shape memory alloys and magnetic fluids

UNIT I MATERIALS AND CLASSIFICATION 9

Solid materials- Classification - Ceramics - composites and metal glasses - Super hard materials - introduction of advanced materials and its manufacturing processes for engineering applications - smart materials - Classification of smart materials.

UNIT II CARBON NANOTUBES 9

Carbon Nano Structures-Introduction - Fullerenes - types of Nanotubes- assemblies- synthesis of carbon nanotubes - C60, C80 and C240 Nanostructures - carbon nanotube interconnects mechanical, optical and electrical properties of carbon nanotubes - Applications of carbon nanotubes.

UNIT III THERMOELECTRIC MATERIALS 9

Thermo Electric Materials (TEM) - Concept of phonon - Thermal conductivity - Specific heat - Exothermic - endothermic processes. Different types of TEM - Bulk TEM Properties -Onedimensional TEM - Composite TEM - Applications.

UNIT V PIEZOELECTRIC MATERIALS 9

Piezoelectric materials (PZT): piezoelectric effect - Di-electric hysteresis - piezoelectric constants - piezoelectric charge constants - dynamic behaviour of PZT transducers - piezoelectric materials and manufacturing techniques (stability, poling and depolarisation).

UNITV SHAPE MEMORY ALLOYS. ELECTRORHEOLOGICAL AND MAGNETORHEOLOGICAL FLUIDS 9

Shape memory alloys (SMA): Shape memory effect and the metallurgical phenomenon of SMA,Temperature assisted shape memory effect - Visco-elastic behaviour - magnetic shape memory effect. Various shape memory alloys. Manufacturing technology of SMAS Electrorheological (ER) and magnetorheological (MR) materials: Characteristics of ER and EM fluids. ER and EM materials.

Total: 45

REFERENCE BOOKS :

1. Michael J. O'Connell, "Carbon Nanotubes: Properties and Applications", CRC/Taylor& Francis, 2006
2. CR Rowe, "Handbook of Thermoelectrics", CRC Press, 1995
3. M.V. Gandhi, B.S Thompson, "Smart materials and Structures", Chapman and Hall, 1992.

4. K. Otsuka, C.M, Wayman, "Shape memory materials", C.U.P, 1998

5. W.Taylor, "Piezoelectricity", George Gorden and Breach Sc. Pub., 1985.

PNT 105 NANOELECTRONICS

L	T	P	C	TCH
3	0	0	4	3

GOAL

The objective of the paper is to comprehend Nanoscience applications in the field of electronics

OBJECTIVES

The course should enable the students to :

1. Understand fundamentals of nanomaterials
2. Learn about MOSFETS
3. Know quantum electron devices
4. Get knowledge on molecular electronics
5. Know memory devices and sensors

OUTCOME

The students will be able to:

1. Know basics of Nanoelectronics and its fabrication tools
2. Understand fundamentals of ´MOSFETS and design of circuits
3. Understand the concept quantum mechanics in electronics
4. Learn molecular devices and its synthesis techniques
5. Understand nanoferroelectronics using Fe-RAM and sensors

UNIT I FUNDAMENTAL OF NANOELECTRONICS **9**

Basics of nanoelectronics - physical fundamentals of Nanoelectronics - basics of information theory - tools for micro and nano fabrication - basics of lithographic techniques for Nanoelectronics - microlithography - nanolithography - tools for nanolithography.

Unit II MOSFETS **9**

Silicon MOSFETS - fundamentals of MOSFET devices - NanoFETS-single electron MOS transistor - split gate transistor - Electron wave transistor - Electron spin transistor - advanced MOSFET concepts - Principles of Single Electron Transistor (SET) - SET circuit design - comparison between FET and SET circuit design.

UNIT III QUANTUM ELECTRON DEVICES **9**

Classical to quantum physics - electrons in mesoscopic structure - Nanoelectronics with tunneling devices and superconducting devices - tunneling element technology - Resonant tunneling Devices

single electron devices - single electron devices for logic and gateapplications - Carbon Nanotube based logic gates - optical devices. Quantum dots - quantumwires and quantum wells

UNIT IV MOLECULAR ELECTRONICS **9**

Molecular electronic devices - Basic Concepts - Self assembled Layers - Charge transport

Mechanisms - Synthesis of Molecular wires and devices-synthesis of two terminal devices - Fabrication of molecular transport devices.

UNIT V MEMORY DEVICES AND SENSORS **9**

Nano ferroelectrics - Ferroelectric random access memory - Fe-RAM circuit design - ferroelectric thin film properties and integration - calorimetric sensors - electrochemical cells - resistive semiconductor gas sensors - electronic noses - identification of hazardous solvents and gases - semiconductor sensor array.

Total: 45

TEXT BOOKS :

1. W.R. Fahrner, "Nanotechnology and Nanoelectronics: Materials, Devices, Measurement Techniques", Springer, 2010.

REFERENCE BOOKS:

1. K.Goser, P.Glosekotter, J.Dienstuhl, "Nanoelectronic and Nanosystems - From Transistors to Molecular Quantum Devices", Springer, 2004
2. Rainer Waser," Nanoelectronics and Information Technology: Advanced Electronic Materials Novel and Devices",Wiley VCH, 2005.
3. Mick Wilson, Kamali Kannangara, Geoff smith, "Nanotechnology: Basic Science and Emerging Technologies", Overseas press, 2005.

PNT 106 HANDLING, SAFETY AND HAZARD ANALYSIS OF NANOMATERIALS

L	T	P	C	TCH
3	0	0	4	3

GOAL

To practice handling of nanomaterials and understand the hazard aspects of nanomaterials

OBJECTIVES

The course should enable the students to :

1. Understand raw material handling
2. Know safety precautions of nanomaterials
3. Learn hazards aspects of nanomaterials
4. Understand industrial policies
5. Get knowledge about case studies towards safety aspects

OUTCOME

The students will be able to:

1. Understand working procedure of nanomaterials and its guidelines
2. Expertise in laboratory safety practice
3. Know effect of nanomaterial risk mitigation
4. Understand the industry protocols for nanomaterial handling
5. Know the effect of nanomaterials on environment

UNIT I: MANUFACTURING GUIDELINES AND PROTOCOLS **9**

Raw material handling - Processing guidelines and safeguards waste disposal - Best practices - nanotoxicology

UNIT II: SAFETY IN NANOMATERIAL PROCESSING **9**

Safety precautions at lab and manufacturing level - Temperature - Pressure and other physical effects - Trouble shooting and safe evacuation methodologies.

UNIT III : HAZARD ANALYSIS OF NANOMATERIALS AND RISK MITIGATION **9**

Effect of nanomaterial exposure on human and living stock, Long term and short term effects - Case studies of Titania - Asbestos and Carbon-nanoparticle exposure

UNIT IV: POLICY FRAMEWORK ON NANOMATERIAL PROCESSING INDUSTRY **9**

Regulatory guidelines - pollution control - Anti-dumping legislation- Policy on clinical trials for nanomaterial based medicines.

UNIT V: CASE STUDIES **9**

Effect of Nanoparticles on air - water and soil - food and food supplements and cosmetics.

Total No: 45

TEXT BOOKS

1) Nanotechnology Environmental health and Safety: Risks Regulation and Management, Matthew Hull and Diana Bowman, Elsevier 2010

2) Nanomaterials : Risks and Benefits., Edited by Igor Linkov and Jeffery Steevens, Nato Science for Peace and Security Series-C, Environmental Security, Springer 2009.

PNT 111 MATERIALS AND ELECTRONICS LAB

L	T	P	C
0	0	4	2

GOAL

The practical session comprises of three areas like fundamentals of basic materials lab, polymer science and Nanoelectronics

MATERIALS LAB

OBJECTIVES

The practical session enable the student to:

1. Determine hall coefficient of semiconductors materials
2. Learn defect centres in semiconductor material
3. Know thermal conductivity of composite materials
4. Understand Optical characterization

OUTCOME

The student will able to:

1. Know p and n type conductivity of semiconductors materials
2. Analysis of defect centres in semiconductors materials
3. Get knowledge about thermal conductivity
4. Learn absorption analysis and concentration of thin films.

LIST OF EXPERIMENT:

1. Determination of hall coefficient of semiconductors materials
2. Analysis of defect centres in polycrystalline material using absorption measurements
3. Determination of thermal conductivity of composite materials
4. Verification of Beer-Lambert's Law and concentration analysis of thin films using spectrophotometer

ELECTRONICS LAB:

OBJECTIVE:

Understand I/V characteristics of FETs, MOSFETS and Fe-RAM circuit design

OUTCOME:

The student will able to:

1. Analysis of ´CNT MOSFETS
2. Know about I/V characteristics of FETs, MOSFETS
3. Get knowledge about Fe-RAM circuit design

LIST OF EXPERIMENT:

1. Analysis of ´CNT MOSFETS´
2. I/V characteristics of FETs
3. I/V characteristics of MOSFETS
4. Fe-RAM circuit design

POLYMER TECHNOLOGY

OBJECTIVE

The practical session enable the student to:

1. Know Polymerization techniques
2. Determination of molecular weight of polymers
3. Learn volatile content in plastics

OUTCOME

The student will able to:

1. Synthesize polymers
2. Get knowledge about characterization of polymers

LIST OF EXPERIMENT:

1. Solution polymerization of acrylonitrile
2. Co -polymerization of styrene and methyl methacrylate
3. Determination of molecular weight of polymers by viscosity and UV spectrophotometer method
4. Determination of moisture and volatile content in plastics / rubbers.

LIST OF EQUIPMENTS :

Experiment No	EQUIPMENTS	TOTAL
	MATERIALS LAB:	
1	Hall effect set up	01
2	UV-Visible Spectrophotometer	01
3	Thermal Conductivity Meter	01
4	PL spectrophotometer	01
	ELECTRONICS LAB:	
5	CNT MOSFETS´	02
6	I/V characteristics of FETs	01
7	I/V characteristics of MOSFETS	01
8	Xilinx-ISE-9.1 I –software tool	01
	POLYMER TECHNOLOGY :	
9	Magnetic Stirrer and glasswares	01
10	Experimental setup for synthesis	01
11	Ostwald viscometer and temperature bath	01
12	ROY apparatus	01

SEMESTER II

PNT 201 NANOMATERIALS IN ENERGY GENERATION AND STORAGE

L	T	P	C	TCH
3	0	0	4	3

GOAL

To learn the concepts of clean energy generation and storage of energies

OBJECTIVES

The course should enable the students to :

1. Introduce them to energy challenges
2. Learn about solar energy
3. Know electrochemical storage of energy
4. Gain knowledge on hydrogen storage
5. Know fuel cells

OUTCOME

The students will be able to:

1. Understand the national and global scenario of energy consummation
2. Understand fundamentas of photovoltaics and its advancement
3. Know principles of batteries and super capacitors
4. Learn importance of storage of hydrogen and its applications
5. Understand basics and working principle of fuel cells and its varieties

UNIT I INTRODUCTION **9**

Energy challenges - Energy Consummation - Indian and global energy uses - Current sources of energy - status of energy map - energy policies - Conservation of energy - Alternative energy sources - development and implementation of renewable energy technologies - role of renewable energy sources - Energy transport - conversion and storage - Sustainable Energy

UNIT II SOLAR ENERGY **9**

Fundamentals of solar cells - types of solar cells - photovoltaic effect - semiconducting materials bandgap theory - band gap engineering - Solar cell properties and design - p-n junction - photodiodes - electron and hole transports - charge carrier generation - recombination - I-Vcharacteristics - Tandem structure -Single junction and triple-junction solar panels - thin film solarcells- solar cell applications solar cell manufacturing process

UNIT III ELECTROCHEMICAL ENERGY STORAGE DEVICES **9**

Thermodynamics of electrochemical reaction - Principle of battery - Rechargeable battery- Li-ionbatteries - Nanostructured materials for Li-ion batteries -Principle of supercapacitor - Advanced supercapacitor technology - Difference between batteries and supercapacitors

UNIT IV HYDROGEN STORAGE **9**

Hydrogen as renewable energy source - Sources of Hydrogen Production - hydrogen storage methods - Direct electrolysis of water - thermal decomposition of water - biological and biochemical methods of hydrogen production

UNIT V FUEL CELLS **9**

Basics of Fuel cells - Difference between batteries and fuel cells - working principle of fuel cells - Fuel cell thermodynamics - fuel cell electrochemistry - Nernst equation - Electrochemical kinetics - Butler - Volmer equation - Fuel cell types - SOFC - MCFC - PAFC - PEFC - Heat and mass transfer in polymer electrolyte fuel cells - water management in PEFCs-Current issues in PEFCs Direct methanol fuel cells (DMFC) - Electrochemical kinetics methanol oxidation - Current issues in DMFCs

Total: 45

TEXT BOOKS :

1. Jose Goldenberg, Thomas Johansson, A.K.N.Reddy, Robert Williams, "Energy for a sustainable world" ,Wiley, 1987
2. J.W.Twidell and A.D.Weir, "Renewable Energy Sources ", ELBS Edition,1986.

REFERENCE BOOKS:

1. Leon Freris, David Infield, "Renewable Energy in Power Systems", Wiley, 2008.
2. K.Kordesch,G.Simader, "Fuelcell and Their Applications", Wiley-Vch,Germany,1996.
3. C.M. Niemeyer and C.A. Mirkin, "Nanobiotechnology, Concepts, Applications and perspectives", Wiley-vch, 2004.
4. D.O.hall and R.P. Overeed, "Biomass Renewable Energy", John Wiley and Sons, 1987

PNT 202 NANOPHOTONICS

L	T	P	C	TCH
3	0	0	4	3

GOAL

To understand the concepts of Nanotechnology in photonics and plasmonics field as well as their applications

OBJECTIVES

The course should enable the students to :

1. Learn about quantum confinement of materials
2. Learn about near field optics
3. Know plasmonics
4. Understand photonics in field of biology
5. Know concepts of photonics

OUTCOME

The students will be able to:

1. Understand photons and different microscopic techniques
2. Understand fundamentals of near field optics and waveguided structures
3. Know principles of surface plasmon resonance and metamaterials
4. Learn interactions of light with cells and DNA interactions
5. Know important features of photonic crystals

UNIT I QUANTUM CONFINED MATERIALS **9**

Introduction to nanoscale interaction of photons and electrons - near field interaction and microscopy - near field optics and microscopy - single molecule spectroscopy - nonlinear opticalprocess. Materials for nanophotonics - quantum confined materials - quantum confinement optical properties with examples

UNIT II NEW APPROACHES IN NANOPHOTONICS **9**

Near-field optics - aperture near-field optics - apertureless near-field optics - near-field Scanning optical microscopy (nsom or snom) - snom based detection of plasmonicenergytransport - snom based visualization of waveguide structures - snom in nanolithography - snom based optical data storage and recovery

UNIT III PLASMONICS **9**

Internal reflection and evanescent waves - plasmons and surface plasmon resonance (spr) - Attenuated total reflection - grating spr coupling - optical waveguide spr coupling - spr dependencies and materials - plasmonics and nanoparticles - metallic nanoparticles - nanorods - metallic nanoshells - local field enhancement

UNIT IV BIOPHOTONICS **9**

Interaction of light with cells - tissues - nonlinear optical processes with intense laser beams - photo-induced effects in biological systems - generation of optical forces - optical trapping and manipulation of single molecules and cells in optical confinement - laser trapping and dissection for biological systems - single molecule biophysics - DNA protein interactions

UNIT V PHOTONIC CRYSTALS **9**

Concept of photonic band gap - important features of photonic crystals - presence of photonic bandgap - anomalous group velocity dispersion - microcavity - effects in photonic crystals - fabrication of photonic crystals -dielectric mirrors and interference filters - photonic crystal laser - pc based LEDs - photonic crystal fibers (pcfs) - photonic crystal sensing.

Total : 45

TEXT BOOKS:

1. Paras N. Prasad, "Nanophotonics", Wiley Interscience ,2004
2. Branda Paz, "A Handbook on Nanoelectronics ", Vedams books, 2008.

REFERENCE BOOKS:

1. B.E.A. Saleh and A.C.Teich, "Fundamentals of Photonics", John-Wiley & Sons, New York, 1993.
2. M. Ohtsu, K. Kobayashi, T. Kawazoe, and T. Yatsui, "Principles of Nanophotonics (Optics and Optoelectronics)", Japan, 2003
3. P.N. Prasad, "Introduction to Biophotonics", John Wiley & Sons, 2003.
4. J. D. Joannopoulos, R. D. Meade and J. N. Winn, "Photonic Crystals", Princeton University Press, Princeton,1995
5. Sergey Edward Lyshevski, "Nano and Molecular Electronics", CRC Press, 2007.

PNT 203 COMPUTATIONAL SCIENCE FOR NANOTECHNOLOGY

L	T	P	C	TCH
3	0	0	4	3

GOAL

To explore methodology behind Computational Science for Nanotechnology

OBJECTIVES

The course should enable the students to :

1. Know principles of Numerical methods
2. Learn Mathematical modeling
3. Understand Computational physics
4. Understand basic concepts of simulation
5. Get knowledge about scientific softwares

OUTCOME

The students will be able to:

1. Get an idea about scientific modelling through numerical algorithms
2. Understand modelling and simulation & its advantages and limitations
3. Know applications of differential equations and its solutions
4. Understand molecular dynamics using simulation
5. Know scientific sofwares for characterization of nanomaterials

UNIT I FUNDAMENTAL PRINCIPLES OF NUMERICAL METHODS **9**

Scientific Modeling - Numerical data and Numerical operations - Numerical Algorithms - Numerical Programs - Numerical Software - Approximations in Mathematical Model building - Numerical integration - Differentiation - Variational finite element methods - Rayleigh's method-Ritz method.

UNIT II MATHEMATICAL MODELING **9**

Mathematical modeling - physical simulation - advantages and limitations -process control - Transport phenomena- concept of physical domain and computational domain - assumptions and limitations in numerical solutions - Finite element method and Finite difference method.

UNIT III COMPUTATIONAL PHYSICS **11**

Numerical Solution of differential equations - Applications to potential well problem - Ab-intio calculations for electron density approximation - Electrons in Periodic potential - Calculation of band structure using plane wave methods - Lanczos method and applications to tight binding Hamiltonians - Calculation of spectral properties - Calculation of phase shifts - Resonance

UNIT IV SIMULATION 9

Basic concepts of simulation - data exchange of the structure - properties and processing of materials - Three dimensional model for capillary nanobridges and capillary forces - Molecular dynamics simulation - Interacting particles with Lennard - Jones potentials.

UNIT V SCIENTIFIC SOFTWARE FOR CHARACTERIZATION 7

Simple scientific software Using Matlab - Mathematica - mechanics - optics and quantum Mechanics - Atomistix and related software - Introduction to Labveiw software - Rietveld analysis for x-ray diffraction - Curve fitting analysis.

Total : 45

REFERENCE BOOKS :

1. S.C. Chapra and R.P.Canale, "Numerical methods for Engineers", Tata McGraw Hill, New Delhi, 2002.
2. R.J. Schilling and S.L. Harris, "Applied Numerical Methods for Engineers using MATLAB and C", Thomson publishers, New Delhi, 2004.
3. Computational Physics, J. M. Thijssen, Cambridge Univ. Press, 1999.
4. Understanding Molecular Simulation, Daan Frenkel and B. Smit, Academic Press, 1996
5. A first course in computational Physics, Paul, L. Pavries, Pub. John Wiley and Sons, 1994.

PNT 204 CHARACTERIZATION TECHNIQUES FOR NANOMATERIALS

L	T	P	C	TCH
3	0	0	4	3

GOAL

To understand Instrumental methods used to characterize Nanomaterials

OBJECTIVES

The course should enable the students to :

1. Understand optical characterization techniques
2. Understand different varieties of spectroscopic techniques
3. Know mechanical characterization of nanomaterials
4. Understand structural characterization
5. Get knowledge about thermal characterization of materials

OUTCOME

The students will be able to:

1. Know luminescence characterization and spectroscopic techniques
2. Know different spectroscopic characterization techniques and interpretation of results

3. Learn hardness, stress and strain characteristics of materials

4. Determine crystal structure using x-ray diffraction

5. Know phase changes, melting points and thermal characterization using DTA, DSC etc.

UNIT I OPTICAL CHARACTERIZATION 9

UV-Vis - IR Spectrophotometer - Fluorescence spectroscopy - Photoluminescence - Room temperature and temperature dependent Photoluminescence - Thermoluminescence - Electroluminescence - Magneto luminescence - Cathodoluminescence - Diffuse reflectance - X ray Photoelectron Spectroscopy (XPS).

UNIT II SPECTROSCOPY 9

Infrared spectroscopy (FTIR) - Raman Spectroscopy - Brillouin Spectroscopy - Dynamic Light Scattering (DLS) - NMR Spectroscopy - ESR Spectroscopy - Inductively Coupled Plasma Spectroscopy - Mossbauer Spectroscopy - Atomic absorption spectroscopy (AAS) - Electron energy loss spectroscopy.

UNIT III MECHANICAL CHARACTERIZATION 9

Micro hardness - fatigue - abrasion and wear resistance - super-plasticity, Nanoindentation - Nanotribology - Nanotribometer - Quartz Crystal microbalance - Friction force microscope -Vibrational spectroscopy - Instrumentation.

UNIT IV STRUCTURAL CHARACTERIZATION 9

X- ray diffraction - Powder and crystal X-ray diffraction - Small angle X-ray Scattering - X-ray absorption Fine Structure (XAFS) - Extended X-ray absorption fine structure (EXAFS) - Scanning electron microscopy - Transmission electron microscopy - confocal microscope - Scanning Probe Microscopy (SPM) - Scanning Tunnelling Microscopy (STM).

UNIT V THERMAL CHARACTERIZATION OF MATERIALS 9

Principle and Instrumentation of Thermogravimetry (TGA) - Differential Thermal Analysis (DTA) and Differential scanning calorimetry (DSC) - Thermo mechanical analyzer (TMA) - Determination of thermo physical parameters.

Total: 45

TEXT BOOKS :

1. Horbarth Willard, Lynne Merritt John Dean "Instrumental Methods of Analysis", Wadsworth publishing company, 2000.

REFERENCE BOOKS

1. B.D. Cullity, "Elements of X -ray Diffraction", 4th Edition, Addison Wiley, 1978

2. Skoog, D.A., Holler, F.J. and Nieman.T.A. "Principles of Instrumentation analysis", 5th Edition, Thomson Learning, 1998.

3. R.M.Rose, L.A.Shepard and J.Wulff, "The Structure and Properties of Materials", Wiley Eastern Ltd

4. Robert F Speyer "Thermal Analysis of Materials", Marcel Dekker New York.

PNT 209 NANOMATERIAL SYNTHESIS AND COMPUTATION LAB

L	T	P	C
0	0	4	2

GOAL

To have hands on experience in the synthesis procedure

OBJECTIVES

The practical session enable the student to:

1. Expert in different synthesis conditions
   a. Chemical synthesis
   b. Sol-gel techniques
   c. Bio route synthesis
2. Understand thin film fabrication techniques
3. Get knowledge about sensor characterization
4. Understand DFT calculations and band structures

OUTCOME

The student will able to:

1. Synthesis different nanostructures using different synthesis conditions
2. Get knowledge about characterization of nanomaterials

LIST OF EXPERIMENTS :

1. Chemical synthesis of CdS nanoparticles
2. Synthesis of different sizes and shapes of CuO nanoparticles using solgel technique
3. A bioroute synthesis to Metal nanoparticles
4. Experimental determination of open circuit voltage and short circuit measurements of thin films using IV characterization
5. Surface plasmon resonance studies of metal nanoparticles using UV-Vis Spectrophotometer
6. Fabrication of Fe2O3 nanoparticles of different sizes
7. Fabrication of nanostructure thin film sensors by spin coating
8. Synthesis of Thin film using Electrodeposition unit
9. Synthesis of thin film in Thermal vacuum coating unit
10. Fabrication of sensors and characterization
11. Synthesis of crystals for phosphor applications
12. Synthesize silver nanocrystals in solution by citrate reduction method and study the effect of capping using optical absorption spectroscopy.

13. Synthesis of Bio nanomaterials using Ultrasonication technique

14. DFT calculations of chalcogenide materials

15. Calculation of band structure using plane wave methods

LIST OF EQUIPMENTS :

Experiment No	EQUIPMENTS	TOTAL
1	Hot plate and glass wares	02
2	Magnetic stirrer and glassware, Furnace	02
3	Distillation apparatus	01
4	Short circuit/ Open circuit voltage Experimental set up	01
5	UV-Visible spectrophotometer	01
6	Synthesis set up	02
7	Spin coating unit	01
8	Electro deposition unit	01
9	Thermal vacuum coating Unit	01
10	Sensors characteristics	01
11	High temperature furnace	01
12	Spectroscopy	01
13	Ultrasonicator	01
14	DFT -Software package	01
15	DFT -Software package	01

SEMESTER III

PNT 308 ANALYTICAL TECHNIQUES - RESULTS AND ANALYSIS LAB

L	T	P	C
0	0	6	2

GOAL

To explore analysis techniques

OBJECTIVES

The practical session enable the student to:

1. Understand Structural and morphological characterization of nanomaterials
2. Get knowledge about Cyclic voltammetry and XPS studies
3. Fabrication of thin films using pulsed laser deposition technique
4. Determination of Bandgap, carrier concentration and conductivity studies of nanomaterials

OUTCOME

The student will able to:

1. Analysis the nanomaterials using different analytical techniques such as XRD, SEM –EDX, XPS, I/V, FTIR, UV- Vis Spectrophotometer and thermal analysis
2. Get knowledge about characterization of nanomaterials

LIST OF EXPERIMENTS

1. Determination of crystallite size measurements of powder particles using Debye scherer method
2. Structural characterization of nanomaterials using Scanning electron microscopy
3. Elemental analysis using Energy-dispersive X-ray spectroscopy
4. Cyclic voltammetry studies of Nano Particles
5. Analysis of XPS spectra of Fe and Fe ions in metal oxides
6. Fabrication of thinfilms using pulsed laser deposition technique
7. Bandgap calculation of CuO thin films using absorption and transmission measurements
8. Determination of carrier concentration of ZnO thin films
9. Conductivity studies of nanomaterials by AC impedance analyzer
10. Phase change analysis determinations using TGA-DSC measurements
11. Effect of Annealing on metal oxide nanoparticles using transmission studies
12. Diffuse reflectance studies of metal nanoparticles using UV-Visible spectrophotometer
13. Determination of functional groups of alkylthiophene using FTIR spectroscopy
14. I-V Characterization of metal oxide nanofilms for photovoltaic applications

LIST OF EQUIPMENT:

Experiment No	EQUIPMENTS	TOTAL
1	Analysis of Spectra - spectra will be provided	04
2	Scanning electron microscopy with EDS	01
3	Scanning electron microscopy with EDS	01
4	Electrodeposition unit	01
5	XPS spectra	04
6	Pulsed laser deposition	04
7	UV - Visible spectrophotometer	01
8	Carrier concentration studies	01
9	AC - impedance analyzer	01
10	TGA - DSC measurements	01
11	High temperature furnace with UV-Visible spectrophotometer	01
12	DRS	01
13	FTIR	01
14	I-V Characteristics - probe station	01

LIST OF ELECTIVES
PNT 701 COLLOID & INTERFACE SCIENCE

L	T	P	C
3	0	0	3

GOAL

To gain a broad knowledge in the surface properties of nanomaterials

OBJECTIVES

The course should enable the students to :

1. Get introduced to colloid materials.
2. Learn about surfactants and its type
3. Study about intermolecular forces
4. Get knowledge on properties of materials.
5. Learn different measurement techniques

OUTCOME

The students will be able to:

1. Learn preparation and characterization of colloids
2. Understand the physics of surfactants
3. Have an idea about different types of forces between particles
4. Understand material properties and interfacial dynamics
5. Know to do characterisation of colloid particles

UNIT I INTRODUCTION **9**

Introduction to colloidal material - surface properties - Preparation - characterization of colloidal particles - Applications of oil recovery - super hydrophilic surfaces - self cleaning surfaces.

UNIT II SURFACTANTS **9**

Surfactant types - Anionic - cationic - Zwitterionic, Gemini and non-ionic surfactants - Theory of Surfactants - CMC - Kraft temperature - Phase behavior of cone surfactant systems - surfactant geometry - packing - emulsions - Micro-emulsions - Gels.

Unit III Intermolecular forces **9**

Intermolecular Forces - Van der Waals forces - Kessorn - Debye - London Interactions - Potential energy curve - Brownian motion - Brownian Flocculation - Surface and interfacial Tension - sessile drop - pendant drop - Surface free energy - Surface tension for curved interfaces - Surface excess and Gibbs equation.

Unit IV Properties of materials **9**

Contact angle - Wetting Young - Laplace equation - Dynamic properties of interfaces - Surface viscosity, Kelvin equation - Electrical phenomena at interfaces (Electronic kinetic phenomena - Electric double layer - short range forces) - DLVO theory - capillary hydrostatics - interfacial hydrodynamics.

UNIT: V MEASUREMENTS TECHNIQUES **9**

Surface tension - Interfacial Tension - Contact angle - Zeta potential - Particle size & its distribution - Electro osmosis phenomena - Streaming potential - Electro viscous flows.

Total: 45

TEXT BOOK

1) P.C Hiemen and R.Rajgopalam," Principle of colloid and surface Chemistry" NY Marcel Dekker, 1997.

REFERENCE BOOKS

1) A.W. Adamson and A.P Gast, "Physical Chemistry of surfaces", Wiley Interscience, NY 2004.

2) D.J.Shaw, "Colloid and surface chemistry", Butterworth Heineman, Oxford,1992.

3) M J Rosen, "Surfactant and Interfacial phenomena", Wiley Inter Science Publication, NY 2004

4) Jacob Israelachvilli, "Intermolecular and Surface Forces", Academic Press, NY 1992.

PNT 702 SOLID STATE OPTOELECTRONIC DEVICES

L	T	P	C
3	0	0	3

GOAL

To understand principle and applications of optoelectronic devices

OBJECTIVES

The course should enable the students to :

1. Get an idea about fundamental of optics
2. Learn optical properties of different devices
3. Know effect of electric field on optical properties
4. Understand fundamental of optical amplifiers
5. Learn basics of photodetectors

OUTCOME

The students will be able to:

1. Understand principles of optoelectronic devices
2. know theory behind optical properties as well as their applications
3. Understand about different modulators and their properties
4. know about design and characterization of optical amplifiers
5. Know principles of photodetector and its performance

UNIT I FUNDAMENTALS **9**

Optoelectronic materials - Semiconductors - compound semiconductors - III-V and II-VI compounds - ZnO - ITO - GaN - direct and indirect band gap - electronic properties of semiconductors - Fermi level - density of states - life time and mobility of carriers - invariance of Fermi level at equilibrium - diffusion - continuity equation - excess carriers - quasi-fermi levels.

UNIT II OPTICAL PROPERTIES **9**

Optical properties - theory of recombination - radiative and non-radiative - absorption edge - photoconductivity - light emitting diodes - LED - device configuration and efficiency - LED structures - light current characteristics and device performance - frequency response and modulation band width - Laser diodes - basic concepts - heterojunction and injection lasers - output characteristics - DER, DBR and quantum well lasers - multiple quantum well structures - surface emitting lasers.

UNIT III ELECTRO OPTICAL PROPERTIES **9**

Birefringence - uniaxial and biaxial crystals - index ellipsoid - electro-optic effect - electro optic retardation. Phase and amplitude modulators - transverse electro optic modulators and design considerations - high frequency modulation considerations - transit time limitations in a lumped modulators - travelling wave modulators. Acousto-optic effect - Raman-Nath and Bragg regime - acousto-optic modulators - magneto optic effects - spatial light modulators.

UNIT IV OPTICAL AMPLIFIERS **9**

Optical Amplifiers (OAs) - Comparative study of OAs - SLAs - FRAs - FBAs - EDFAs and PDFAs based on signal gain - pump efficiency - Noise figure - insertion loss and bandwidth - Design and Characterization of forward pumped EDFAs.

UNIT V PHOTODETECTORS **9**

Photo-detectors - performance criteria of a photo-detector, expressions for quantum efficiency, responsivity - photoconductors and photodiodes - PIN diodes - hetero-junction diodes and APDs characteristics and device performance - high speed measurement photoresistors - CCDs, photomultiplier tube - solar cells efficiency - recent developments dye sensitized solar cells - noises in photo-detectors - SNR - noise equivalent power.

Total : 45

TEXT BOOKS

1. AmnonYariv, "Optical Electronics", Holt Rine hart & Winston, Philadelphia, 1991
2. Bhattacharya P., "Semiconductor Optoelectronic Devices", PHI, New Delhi.2nd Edn 2009

REFERENCE BOOKS:

1. Ben G. Streetmann& Sanjay Banerjee, Solid State Electronic Devices, PHI, New Delhi, 6th Edition, 2009.
2. Ghatak A. and Thyagarajan K., "Optical Electronics", Cambridge University Press, New Delhi, 1994.
3. V.V. Rampal, "Photonics Elements and Devices", Wheeler, Allahabad, 1992.
4. Amnon Yariv and Pochi Yeh, "Optical Waves in Crystals", Wiley & Sons, 2003.

PNT 703 NANO BIOTECHNOLOGY

L	T	P	C
3	0	0	3

GOAL

To educate the students on the structural and functional principles of Nano biotechnology and on its applications of Nano biotechnology as Bio-sensors in Bioelectronics.

OBJECTIVES

The course should enable the students to :

1. Learn the development of Bio - Nanotechnology
2. Study about structural principles of Nano bio technology
3. Understand DNA template electronics
4. Learn about bio sensors and bio electronics
5. Read about application of Nano bio technology

OUTCOME

The students will be able to:

1. Know the effect of Nanotechnology in biology
2. Know about construction of nanomachines and its limits
3. Get an idea about sequencing and manipulation of bioelectronics
4. Understand functionalization of sensing substrates and learn about nanomaterial based biosensors
5. Gain knowledge in its application.

UNIT I FUNCTIONAL PRINCIPLES OF NANOBIOTECHNOLOGY 9

From Biotechnology to Nano biotechnology - Information driven Nanoassembly - Energetics - Top down and bottom up approach for building nanomaterials - Chemical Transformation Biomaterials - Machine - Phase Nano biotechnology

UNIT II STRUCTURAL PRINCIPLES OF NANOBIOTECHNOLOGY 9

Construction of Nanomachines - The Raw Materials: Biomolecular Structure and Stability - Protein Folding - Self-Assembly - Self-Organization - Molecular Recognition - Atomicity limits - the tolerance of combining sites - Flexibility

UNIT III DNA TEMPLATED ELECTRONICS 9

Sequence - specific molecular lithography - Single Biomolecule - Manipulation for Bioelectronics - DNA as a semiconductor.

UNIT IV BIOSENSORS AND BIOELECTRONICS **9**

Functionalization of Sensing Substrates - Biochip - Nanosensors-Miniaturization of Biosensors - Nanomaterial Based Biosensors - Electron Transfer of Biomolecules - Nanoparticle - Biomaterial Hybrid Systems for Sensing and Electronic Devices - Effect of Biosensor in biological and physicochemical techniques

UNIT V APPLICATIONS OF NANOBIOTECHNOLOGY **9**

Early medical diagnostics - drug targeting - drug delivery - nano surgery and other biomedical field - Molecular Nanotechnology - Case Studies - Nanotube synthesis - A general nanoscale assembler- Nanosurveillance

Total: 45

REFERENCE BOOKS:

1. Niemeyer and Mirkin ed. "Nanobiotechnology: concepts, applications & perspectives" Wiley-VCH, Weinheim 2004.
2. Jain, KK. "Nanobiotechnology in molecular diagnostics: current techniques and Applications", Horizon Scientific Press Norwich, United Kingdom, 2006.

PNT 704 NANOCOMPOSITES

L	T	P	C
3	0	0	3

GOAL

To give a comprehensive idea about nanocomposites, their properties, synthesis focussing on biodegradable polymer nanocomposites

OBJECTIVES

The course should enable the students to :

1. Get comprehensive knowledge about nanocomposites
2. Learn different types of nanocomposites
3. Know about synthesis of nanocomposites
4. Read about mechanical properties of nanomaterials
5. Get knowledge on biodegradable polymer nanocomposite

OUTCOME

The students will be able to:

1. Know about fundamentals of nanocomposites
2. Have an knowledge about different structures and application of nanocomposites
3. Have an idea about preparation technologies of nanocomposites
4. To know about capability of nanofillers and its properties
5. know about biodegradable ability and its properties

UNIT I TERMINOLOGY **9**

Definition of nanocomposite - nanofillers - classification of nanofillers - carbon and - non carbon based nanofillers - synthesis and properties of fillers.

UNIT II TYPES OF NANOCOMPOSITES **9**

Types of nanocomposties - Structures - particles - thin films - wires - porous systems Applications: electrical - magnetic - optical - Nanocomposites based on polymer matrix - polymer / polymer - ceramic / polymer - metal / polymer - carbon nanotube / polymer Polyimide Matrices - Polypropylene and Polyethylene Matrices - Liquid Crystal Matrices - Epoxy and Polyurethane Matrices - Rubber Matrices.

UNIT III SYNTHESIS OF NANOCOMPOSITES **9**

Preparation technologies - mechanical alloying - sol-gel synthesis - melt spraying - Direct Mixing, Solution Mixing - In-Situ Polymerization-In-Situ Particle Processing Ceramic/Polymer Composites - In-Situ Particle Processing Metal/Polymer Nanocomposites - Modification of Interfaces - Modification of Nanotubes -Modification of Nanoparticles.

UNIT IV MECHANICAL PROPERTIES OF NANOCOMPOSITES **9**

Mechanical Properties - Modulus and the Load - Carrying Capability of Nanofillers - Glass Transition and Relaxation Behavior - Permeability - Dimensional Stability Contents - Thermal Stability and Flammability

UNIT V BIODEGRADABLE POLYMER NANOCOMPOSITES **9**

Properties - Biodegradability - Foam processing - of biodegradable nanocomposites - Nanocomposites based on water soluble polymers - Crystallization behaviour - Nanocomposites containing functionalized nanoparticles: Organic and polymer materials for light-emitting diodes polymer Photo-oxidation of emitting.

Total: 45

TEXT BOOKS:

1. P.M. Ajayan "Nanocomposite Science and Technology "Wiley Verlag GmbH, Weinheim, 2003

REFERENCE BOOKS:

1. Yiu-Wing Mai, Zhong-Zhen Yu, Polymer nanocomposites":,Woodhead Publishing Limited and CRC Press LLC, USA, 2006.
2. P.M. Ajayan, L.S. Schadler, P.V. Braun, "Nanocomposite Science and Technology" WILEY-VCH Verlag GmbH Co. KGaA, Weinheim. 2003.

PNT 705 MICRO AND NANO ELECTROMECHANICAL SYSTEMS

L	T	P	C
3	0	0	3

GOAL

To learn fundamentals and applications of micro/nano sensors and actuators.

OBJECTIVES

The course should enable the students to :

1. Learn fundamentals of microelectronics
2. Read about micromechanics technology
3. Get an idea about properties of materials and its design
4. Study about architectures of MEMS and NEMS devices
5. Get Knowledge about nanomachining of NEMS

OUTCOME

The students will be able to:

1. Understand the potential of Silicon technology
2. Know about MEMS; its synthesis techniques and packaging of MEMS devices
3. Know about designing of MEMS and different materials
4. Have an idea about miniaturization, optical MEMS, RFMEMS and different varieties
5. Understand the fabrication process and application in Nanoscale

UNIT I: DEVELOPMENT OF MICROELECTRONICS **9**

Potential of silicon technology - nanostructure region - complexity problem and limits - challenges in nanoelectronics - semiconductors as based materials - band diagram of semiconductor - in homogeneous semiconductor band diagram - different types of transistor integration - micro miniaturization process - methods and limits - scaling laws - microelectronic and mechanical system (MEMS) - Definitions - MEMS impact - dimensions - market development - driving forces - application fields.

UNIT II: MICRO ELECTRO MECHANICAL SYSTEMS (MEMS) **9**

Micromechanics technology - micromechanics for nano electronics - integrated optoelectronics. Silicon micro machining - bulk micro machining - surface micro machining - Micro systems fabrication techniques - photo lithography - ion implantation - diffusion - oxidation - CVD -PVD - sputtering - single crystal reactive etching - LIGA - X-ray based fabrication - packaging of MEMS devices - three level micro systems packaging - device level packaging - system level packaging - interface in micro system packaging - packaging technology - sealing - 3D packaging - assembly of micro system - selection of packaging materials.

UNIT III : MATERIALS AND DESIGN OF MEMS **9**

Properties of solid state materials - Single crystal silicon - Poly silicon - Silicon dioxide - silicon nitride - germanium based materials - metals - silicon carbide - diamond - III - V materials - piezo electric materials - semiconductor effects - comparison of materials. Design - considerations - selection of materials - selection of manufacturing process - process design - photo lithography - thin film fabrication - geometry shaping - mechanical design - thermo mechanical loading thermo mechanical stress analysis - dynamic analysis - interfacial fracture analysis - mechanical designing methods - computer aided designing.

UNIT IV : MEMS AND NEMS DEVICES **9**

Nanoelectronic device architectures - Crossbar multiplexers and demultiplexers, Limits of Miniaturization - Inertial sensors - accelerometer - gyroscope - micromechanical pressure sensors - piezo resistive - capacitive - micro robotics - micro channel heat sinks - optical MEMS - visual display - precision optical platform - optical data switching - RF MEMS - MEMS variable capacitors - MEMS switches - Resonators.

UNIT V: NANO ELECTROMECHANICAL SYSTEMS **9**

Introduction - nano machining of NEMS based upon electron beam lithography - Nanostructures - Applications of nanostructures- Nano electromechanical systems fabrication - nano imprint lithography - polymeric nano fiber templates - focused ion beam doping wet chemical etching - Stencil lithography and sacrificial etching - large scale integration - future challenges - applications.

Total : 45

TEXTBOOK:

1. Foundations of MEMS, C. Liu, Prentice Hall, 2006, ISBN: 0131472860.
2. Microsystems Design,S. D. Senturia, Kluwer, 2001, ISBN: 0792372468 (e-book available).
3. "Micromachined Transducers Source book", G.T.A. Kovacs, McGraw Hill, 1998, ISBN: 0071164626.
4. Fundamental of Microfabrication, Marc Madou, CRC Press, 2002, ISBN: 0849308267.
5. Foundations of Nanomechanics, Andrew N. Cleland, Springer, 2003, ISBN: 3642078214.

REFERENCES:

1. K.Goser, P. Glosekotter and J. Dienstuhl, "Nanoelectronics and Nanosystems - From Transistors to Molecular Quantum Devices" Springer, 2004.
2. Tai-Ran Hsu, "MEMS & Microsystems Design and Manufacture", Tata McGraw - Hill Publication, 2001.
3. P. Rai Choudhury, "MEMS and MOEMS Technology and Applications", PHI learning private Ltd, 2009.
4. Mohamed Gad-el-Hak, "The MEMS Handbook", CRC Press, 2002.

PNT 706 ENVIRONMENTAL NANOTECHNOLOGY

L	T	P	C
3	0	0	3

GOAL

Application of Nano materials towards environmental protection

OBJECTIVES

The course should enable the students to :

1. Read about application of nanomaterial in Environmental aspects
2. Study about synthesis of bio nanomaterials
3. learn about nanoremediation
4. Understand environmental Remediation technologies
5. Read about application of industrial ecology to Nanotechnology

OUTCOME

The students will be able to:

1. Know about effect of nanomaterials on Environment
2. Know about physio and chemical approaches in synthesis of Nano biomaterials
3. Identify and characterize hazardous waste in nanoscale and remediation process
4. Know about different thermo, physio, chemical methods in nano remediation
5. Have an idea about toxicity of nanomaterials and its sustainability process

UNIT I NANOMATERIALS FOR ENVIRONMENTAL PROTECTION 9

Nano technology processes - Nano Engineering materials for Pollution Prevention - Green Chemistry, Energy efficient resources and materials - Nano technology products - Nanomaterials (nanostructures) Nanodevices and nanosystems.

UNIT II SYNTHESIS OF NANOMATERIALS 9

Synthesis of nanomaterials by Physico-chemical approaches - Bionanocomposites : Nano particles and Microorganisms - Microbial Synthesis of Nano materials - Biological Methods for Synthesis of nano-emulsions using bacteria - Fungi and 5 Actinomycetes - Plants based nanoparticle synthesis - Nano composite biomaterials - Fibres, Devices and Structures - Nano Bio systems.

UNIT III NANOTECHNOLOGY IN REMEDIATION 9

Nanoremediation - Identification and characterization of Hazardous waste - Nano Pollution - Air-Water - Soil Contaminants - Identification and Characterization of Organic and inorganics - Environmental cleanup technologies.

Nanomaterials-Remediation - Nano Membranes - Nano Meshes - Nano Fibres - Nano Clays and Adsorbents - Zeolites - Nano Catalysts - Bio Polymers - Single Enzyme Nano particles - Bio Metallic Iron Nano Particles - Nano Photo catalysis.

UNIT IV NANO REMEDIATION TECHNOLOGIES **9**

Environmental Nano Remediation Technology - Thermal - Physico-Chemical and Biological Methods - Nano Filtration for treatment of waste - removal of organics & inorganics and pathogens - Nanotechnology for water remediation and purification. Treatment of hi-tech industrial waste waters using nano particles/ modified structures/devices. Environmental Benefits of nanomaterials.

UNIT V SUSTAINABLE NANOTECHNOLOGY **9**

Application of industrial ecology to nanotechnology - Fate of nanomaterials in environment - environmental life cycle of nano materials - environmental and health impacts of nano materials - toxicological threats - eco-toxicology - exposure to nano particles - biological damage - threat posed by nano materials to humans - environmental reconnaissance and surveillance. Corporate social responsibility for nanotechnology - Nano materials in future - implications.

Total : 45

REFERENCES BOOKS:

1. Enviro-nanotechnology by Mao Hong fan, Chin-pao Huang, Alan E Bland, Z Honglin Wang, Rachid Sliman, Ian Wright. Elsevier, 2010.
2. Nanotechnology: Importance and Application by M.H. Fulekar, IK International, 2010.
3. Nanotechnologies, Hazards and Resource efficiency by M. Steinfeldt, Avon Gleich, U. Petschow, R. Haum. Springer, 2007.
4. Nanotechnlogy: Health and Environmental risk by Jo Anne Shatkin. CRC press, 2008.
5. Handbook of Nanofabrication. Edited by Gary Wiederrcht.Elsevier, 2010.
6. Nanoporous materials: Advance techniques for characterization, Modeling and Processing. Edited by Nick KanelloPoulos. CRC press, 2011.

PNT 707 MICRO/NANOFLUIDICS

L	T	P	C
3	0	0	3

GOAL

Understanding of new and advanced field, Nanofluidics

OBJECTIVES

The course should enable the students to :

1. Learn about physics of fluids at micro and nanometer scale.
2. Study about microfluidic system assembly and its fundamental aspects.
3. Have an knowledge about surface phenomenon of nano fluidics.
4. Read basics of hydrodynamics at nanoscale.
5. Learn about electro kinetic effects.

OUTCOME

The students will be able to:

1. Know about fabrication of micro fluidics and nano fluidics devices.
2. Have an idea about different kinetics based microfluidics and computing.
3. Know about solid liquid interface phenomena and physics behind it.
4. Get knowledge about electro kinetic effects and super hydrophobicity.
5. Understand the effect of kinetics and droplet all based microfluidics.

UNIT I : PHYSICS OF FLUIDS **9**

Physics of fluids at the micrometer and nanometer scale - laminar flow -fabrication of microfluidics and nanofluidic devices - applications of nanofluidics in biology

UNIT II: MICROFLUDICS **9**

Micro-fluidic system assembly - Fundamental aspects of fluid Mechanics - scaling laws - flow transport at small length scales - Capillary - driven - pressure driven electro-kinetic based microfluidics - multi-phase flow - Micro/nanofluidic computing

UNIT III : NANOFLUIDICS AND SURFACE PHENOMENON **9**

Nanofluidics - surfaces - liquid structure near solid - liquid interfaces - simple liquids - layering electrolytes - Poisson - Boltzmann equation - Debye Hückel approx - nanofluidic transistors - nanofluidic memory

UNIT VI: HYDRODYNAMICS **9**

Hydrodynamics at small scales - laminar flow - slip versus no-slip - mixing - Electro kinetic effects - solid - liquid interfaces - interaction - adsorption - desorption - three phase systems - capillary forces - wetting - superhydrophobicity - applications of superhydrophobics

UNITV : ELECTROKINETICS **9**

Electrokinetic effects - electroosmotic pumping - electroviscous effect - electrophoresis and separation techniques - colloids - surface reconstruction - dangling bonds - surface states droplet - based microfluidics and complex fluids flow - micro-mixing - pumping systems - cell based microfluidics.

Total : 45

TEXT BOOK

1. Nam-Trung Nguyen, SteveWereley, "F undamentals and Applications of Microfluidics"

REFERENCE BOOKS

1. H.M. Rosenberg," Introduction to Theory of Solids", Oxford University Press, 1995
2. HenrikBruus, "Theoretical Microfluidics" Oxford publishers, 2007
3. Patrick Tabeling," Introduction to Microfluidics " Oxford publishers, 2010.

PNT 708 CARBON NANO-STRUCTURES AND ITS FUNCTIONALISATIONS

L	T	P	C
3	0	0	3

GOAL

To understand about carbon nano structures and its functionlisation.

OBJECTIVES

The course should enable the students to :

1. Study about diamond particles in nano scale
2. Learn about DLC and its techniques.
3. Get knowledge about nano crystalline diamonds.
4. Learn about CNT
5. Know about functionalisation of CNTs

OUTCOME

The students will be able to:

1. Know different techniques of diamond nano particles.
2. Understand the classification of DLC and its properties.
3. Synthesize nano crystalline diamond films and stepwise treatment process.
4. Get an idea about structure of CNT ,its properties, and synthesis methods.
5. Have an idea about covalent and non covalent functionalization and deposition process.

UNIT I DIAMOND **9**

Diamond - nanodiamond particles - nanodiamond particles synthesis - high pressure high temperature technique - chemical methods - using energetic particles and beam. Applications of nanodiamond particles

UNIT II DLC **9**

Diamond - like Carbon films (DLC) - classification of DLC - properties and applications of DLCs - internal stress and adhesion - coating morphology - porosity and diffusional property - DLC/graphite transformation - optical properties - electrical properties - mechanical properties - chemical resistance - tribological properties - deposition techniques of DLC films

UNIT III NCD **9**

Nanocrystalline diamond (NCD) films - pretreatment processes to enhance the nucleation of NCD films - properties and applications of NCD films - tribology - electron emission - electrochemical electrodes - conformal coatings - deposition of NCD films

Unit IV CNT **9**

Carbon nanotube (CNT) - structure of CNT - synthesis of CNT - electronic - vibrational - mechanical and optical properties of CNT - applications of CNT - fabrication of Fullerene (C60).

UNIT V FUNCTIONALIZATION OF CNTS **9**

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.

Total : 45

TEXT BOOKS :

1 Liming Dai "Carbon Nanotechnology"

2. CNR Rao and A. Govindaraj "Nanotubes and Nanowires"- RCS Publishing- 2007

REFERENCES

1. J Robertson, "Diamond-like Amorphous Carbon" - Materials Science and Engineering 37 (2002) 129-281.
2. Olga A.Shenderova, Dieter M. Gruen William A "Ultrananocrystalline Diamond: Synthesis, Properties, and Applications" - andrew Publishing Norwich, New York, U.S.A.
3. "Physical properties of Carbon Nanotube"
4. R Satio"Applied Physics of Carbon Nanotubes : Fundamentals of Theory, Optics and Transport Devices".
5. Michael J. O'Connell, "Carbon Nanotubes: Properties and Applications"

PNT 709 NANOTECHNOLOGY IN HEALTH CARE

L	T	P	C
3	0	0	3

GOAL

To give the students an overview of the applications of Nanotechnology in Health care

OBJECTIVES

The course should enable the students to :

1. Read about human anatomy and pharmaceutical effect.
2. Study antibody based diagnostic techniques.
3. Learn about diagnostic techniques.
4. Understand about new generation prosthetic and medical implants.
5. Get an idea about different methods of diagnosis.

OUTCOME

The students will be able to:

1. Get an idea about human physiology and pharma delivery system.
2. Know about antibody therapy, immuno sensors and disorder.

3. Know about different diagnostic methods, medical devices and computation.

4. Have knowledge about different implant models and methods.

5. Know about PCR animation, DNA profiling and different characteristic techniques.

UNIT I NANOTECHNOLOGY IN PHARMACEUTICAL APPLICATIONS 9

Human anatomy - Form function and physiology - Developmental prolog - principle of development - Neurophysiology - sensory physiology and muscle physiology - Trends in nanobiotechnology - Protein - and peptide - based compounds for cancer - diabetes - infectious diseases and organ transplant - therapeutic classes - focused pharmaceutical delivery systems.

UNIT II IMMUNOASSAY TECHNIQUES 9

Understanding of antibody - based diagnostic techniques (immunoassay) - micro - and nano immuno sensors - Bio-Barcode Assay - use of magnets - gold - DNA and antibodies therapies and diagnostics for cancer and central nervous system disorders.

UNIT III IMPROVED MEDICAL DIAGNOSTICS 9

Improved diagnostic products and techniques - in vivo imaging capabilities by enabling the detection of tumors - plaque - genetic defects and other disease states - ability to control or manipulate on the atomic scale - medical devices - logic and intelligence embedded into medical devices - stand alone sensing and computing devices.

UNIT IV PROSTHETIC AND MEDICAL IMPLANTS 9

New generations of prosthetic and medical implants - artificial organs and implant sacrificial scaffolds or biosynthetic coatings - biocompatibility and reduced rejection ratio retinal - cochlear and neural implants - repair of damaged nerve cells and replacements of damaged skin - tissue and bone.

UNIT V METHODS FOR DIAGNOSIS 9

Animation of the PCR - DNA Profiling - Cantilever Sensors - Targeted Drug Delivery - Magnetic Nanoparticles - Cancer cell targeting - Stem Cell Scaffolds - Electrochemical Impedance Spectroscopy (EIS) - Tethered Lipid Membranes.

Total: 45

REFERENCE BOOKS:

1. Brian, R Eggins "Chemical Sensors and Biosensors", Wiley; New York, Chichester;2002.

2. L.Gorton "Biosensors and modern biospecific analytical techniques", Wilson & Wilson's Elsevier, Amsterdam, London, 2005.

3. Electrochemical Methods: Fundamentals and Applications", Allen J Bard, Larry R Faulkner, Wiley, New York, Chichester, 2nd ed.; 2001.

4. M. Vladimir M. Mirsky "Ultrathin Electrochemical Chemo- and Biosensors: Technology and Performance in Springer Series on Chemical Sensors and Biosensors" Springer, Berlin; 2004

PNT 710 NANO-MATERIAL BASED SENSORS AND ACUTATORS

L	T	P	C
3	0	0	3

GOAL

To learn about the Nano Materials based Micro, Nano Sensors And Actuators - its manufacturing and properties

OBJECTIVES

The course should enable the students to :

1. Learn about sensor characteristics.
2. Get an view about inorganic sensors.
3. Study about optical and sensors.
4. Learn about nano acutators
5. Learn about different detectors and its application

OUTCOME

The students will be able to:

1. Know about different sensors and its characteristics.
2. Know different dimensions of inorganic sensor materials. 3. gain deep knowledge about optical and pressure effect on sensor characteristics.
4. Get an idea about classification of nanoacutators.
5. Know about bio-receptors, bio detectors , nano array based detectors.

UNIT I SENSOR CHARACTERISTICS **9**

Active and Passive sensors - Static characteristics - Accuracy - offset and linearity - Dynamic characteristics - First and second order sensors - Structural properties - Electric and magnetic properties - fundamentals in manufacturing technologies of sensors.

UNIT II INORGANIC SENSORS **9**

Density of states (DOS) - DOS of 3D, 2D, 1D and 0D materials - one dimensional gas sensors - gas sensing with nanostructured thin films - absorption on surfaces - metal oxide modifications by additives - surface modifications - AMR - Giant and colossal magneto resistors - magnetic tunneling junctions

UNIT IV OPTICAL AND PRESSURE **9**

Optical radiation sensors - Physics of optical radiation sensing devices - Technologies in micro and nano-manufacturing - Plasmon resonance sensors with nano particles - Physics of pressure measurement - Classification - MEMS technologies in pressure sensors - Piezo resistive sensors - Capacitive sensors.

UNIT IV NANOACTUATORS **9**

Actuators - Classification - Physical principles of actuators - actuators manufacturing - MEMS - Nanoactuators.

UNIT V DETECTORS AND APPLICATIONS **9**

Bio receptors - Bio detectors - Nano array based detector - Nano Particle based detector - Ultrasensitive detection of pathogenic biomarkers - Ultra-sensitive detection of single bacteria.

Total: 45

REFERENCE BOOKS:

1. Charles Kittel, "Introduction to solid state physics", 8th edition, John Wiley and Sons, 2004.
2. Stephen Beeby, Graham Ensell, Michael Kraft, Neil White, "MEMS Mechanical Sensors", ARTECH HOUSE, INC.,Norwood. 2004,
3. Fraden, Jacob, "Handbook of modern sensors: physics, designs, and applications 3rd ed.", Springer Verlag, NewYork, 2004.

PNT 711 ENERGY MANAGEMENT

L	T	P	C
3	0	0	3

GOAL

This course is aimed at providing the students the basics of energy conservation methods, energy auditing and the economical benefits.

OBJECTIVES

The course should enable the students to :

1. Know basics of energy conservative methods
2. Learn about energy audit.
3. Know about conservation of energy
4. Learn about importance of energy economics
5. Learn about application of management in energy sector.

OUTCOME

The students will be able to:

1. Have knowledge about global energy scenario and conservation policies.
2. Get an idea about purpose methodologies and procedures of energy auditing.
3. Have brief view about total energy systems and conservation method.
4. Know about economics of energy.
5. Get a review of energy management through case studies.

UNIT I SOURCE OF ENERGY **10**

Energy Scenario - Principles and Imperatives of Energy Conservation - Various Sources - Alternative -non conventional energy sources - Alternative energy sources - wind - Solar energy - Energy Consumption Pattern - Resource Availability - Role of Energy Managers in Industries.

UNIT II ENERGY AUDITING **15**

Energy Audit - Purpose - Methodology with respect of Process Industries - Power Plants - Boilers etc, - Characteristic Method Employed in Certain Energy Intensive Industries - Various Energy Conservation Measures in Steam System - Losses in Boiler - Methodology of Upgrading Boiler Performance - Energy Conservation in Pumps - Fans - Aerators Compressors - Air conditioning and refrigeration systems - Function necessity.

UNIT III ENERGY CONSERVATION **10**

Total Energy Systems - Concept of total Energy - Advantages & Limitations - Total Energy System & Application - Potential & Economics of total Energy systems - water - heat recovery. Potential Areas for Conservation in Various Industries - Energy Management Opportunities in Electrical Heating - Lighting System - Cable Selection - Energy Efficient Motors - Factors Involved in Determination of Motor Efficiency.

UNIT IV ENERGY ECONOMICS **5**

Importance of Energy Management - Energy Economics - Discount Rate - Payback Period - Internal Rate of Return, Life Cycle Costing.

UNIT V Applications **5**

Case studies on Sugar Industry - Thermal Power Plant - Petrochemical Industries - Educational Institutions.

Total: 45

TEXT BOOKS :

1. Trivedi, P R, Jolka K R, "Energy Management", Commonwealth Publication, 1997.
2. Witte, Larry C, "Industrial Energy Management & Utilization", Hemisphere Publishers, 1988.

REFERENCE BOOKS:

1. CB Smith, "Energy Management Principles", Pergamon Press, 2004
2. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management & Case Study, Hemisphere, Washington, 1980.

PNT 712 BIOINFORMATICS

L	T	P	C
3	0	0	3

GOAL

OBJECTIVES

The course should enable the students to :

1. Get introduced to basics of bio informatics
2. Learn about sequencing and phylogenetic analysis
3. Gain knowledge on structural bioinformatics
4. Learn about information in omics
5. Get an idea about basic concepts in biomolecular simulation

OUTCOME

The students will be able to:

1. Understand a new field bioinformatics and its fundamentals.
2. Know different sequencing methods and methods of phylogenetic analysis.
3. Have knowledge of experiment methods for protein structure and basic concepts.
4. Understand the database information through sequencing and geneomics.
5. Understand the basics and advanced techniques of biomolecular simulation.

UNIT I INTRODUCTION TO BIOINFORMATICS AND BIOLOGICAL DATABASE 10

Basics of bioinformatics and its relation with molecular biology - Elementary Commands and Protocols - Introduction to Biological databases - organization and management of databases - searching and retrieval of information from world wide web - Nucleic acid databases (NCBI, DDBJ and EMBL), Protein databases (Primary, Composite and Secondary) - Specialized Genome databases - (SGD, TIGR, and ACeDB) - Structure databases (CATH, SCOP, and PDBsum) - Special topics in Bioinformatics - DNA mapping and sequencing - maligment - Large scale - sequencing methods - shortgun and sanger method - DNA sequencing Genome mapping - map assembly - Comparative sequence analysis - SNPs and Haplotypes.

UNIT II SEQUENCING ALIGNMENT AND PHYLOGENETIC ANALYSIS 10

Alignment - Local - Global alignment - pairwise and multiple sequence alignments. Concept of gap penalty and e-value - Alignment algorithms - Dynamic programming in sequence alignment - Needleman-Wunsch Algorithm and Smith Waterman Algorithm - Aminoacid Substitution matrices (PAM,BLOSUM) - Sequence similarity search with database - BLAST and FASTA and tree building - Homology - phylogenetics - Methods of phylogenetic analysis - role of multiple sequence alignment algorithms in phylogenetic analysis - Automated tools for phylogenetic analysis - Construction of phylogenetic tree.

UNIT III STRUCTURAL BIOINFORMATICS **9**

Protein secondary structure - Experimental methods for protein structure determination - Protein tertiary structure modelling - Protein quaternary structure modelling - Basic concepts - Energy landscapes - Docking algorithms - Cn3D - rasMol and SPDB in homology modelling - Protein Interaction

UNIT IV INFORMATICS IN OMICS **7**

Metabolic pathway database (KEGG pathway database) - Next-Generation Sequencing - Microbial Genomes & Metagenomics - Analysis of Microarray Data - Chemo-informatics and Chemical databases - Systems Biology

UNIT V BIOMOLECULAR SIMULATION **9**

Basic concepts - Units and derivatives - Force field and energy landscape - Truncation of nonbonded interactions Conformational Sampling - Minimization and algorithms - Molecular dynamics - Ensembles (statistical mechanics) - Monte Carlo simulations - Solvation - Periodic boundary condition - Ewald summation - Implicit solvent model and continuum electrostatics - Monte Carlo simulation on parallel computers Advanced Techniques - Replica-exchange - Restraint potentials - Free energy calculations - Membrane simulations.

Total: 45

REFERENCE BOOKS:

1. David W. Mount , "Bioinformatics: Sequence and Genome Analysis" CSHL Press, 2001.
2. Claverie, J.M. ,Notredame C. "Bioinformatics for Dummies" Wiley Editor, 2003
3. Lesk, A.M. "Introduction to Bioinformatics". Oxford University Press, 2002.
4. Rastogi, S.C., Mendiratta, N. and Rastogi, P. "Bioinformatics: Concepts, Skills & Applications", CBS Publishers & Distributors, New Delhi, 2004.

SEMESTER IV

M.Tech. NANOTECHNOLOGY

PROJECT WORK (PHASE I)

L	T	P	C
0	0	12	6

GOAL

To develop the student's skills and enable innovation in design and fabrication work from the theoretical and practical skill acquired from the previous semesters.

OBJECTIVES

The course should enable the students to:

1. Select and work on application in the field of Nanotechnology
2. Implement their skills acquired in the previous semesters to practical problems
3. Apply and enhance the knowledge acquired in the related field
4. Make the students come up with new ideas in their area of interest

OUTCOME

At the end of the course the student should be able to:

1. Appreciate various aspects of the curriculum which support students in increasing their mastery
2. Get an idea and develop confidence in designing, analyzing and executing the project
3. Develop knowledge of latest trends in fabrication and relate their ideas to industrial applications
4. Have complete understanding of making a product

NOTE:

The objective of the project work is to enable the students on a project involving theoretical and experimental studies related to the branch of study. Every project work shall have a guide who is the member of the faculty of the institution. Twelve hours per week shall be allotted in the time table and this time shall be utilized by the students to receive the directions from the guide, on library reading, laboratory work, computer analysis or field work as assigned by the guide and also to present in periodical seminars on the progress made in the project.

Each student will be assigned any one of the following types of project/thesis work:

(a) Industrial case study / Research Work report

(b) Preparation of a feasibility report

(c) Thesis by experimental research, and

(d) Design and development of equipment.

Each report must contain student's own analysis or design presented in the approved format.

Sessional marks will include

(a) Evaluation of the student's progress

(b) Degree of involvement and participation

(c) Merit of the project

A student will have to defend his/her project/thesis and credit will be given on the merits of presentation and viva-voce examination.

PROJECT WORK (PHASE II)

L	T	P	C
0	0	24	12

GOAL

To develop the student's skills and enable innovation in design and fabrication work from the theoretical and practical skill acquired from the previous semesters.

OBJECTIVES

The course should enable the students to:

1. Select and work on real life application in the field of Nanotechnology
2. Implement their skills acquired in the previous semesters to practical problems
3. Apply and enhance the knowledge acquired in the related field
4. Make the students come up with new ideas in his area of interest

OUTCOME

At the end of the course the student should be able to:

1. Appreciate various aspects of the curriculum which support students in increasing their mastery
2. Get an idea and develop confidence in designing, analyzing and executing the project
3. Develop knowledge of latest trends in fabrication relate their ideas to industrial applications
4. Have complete understanding of making a product

NOTE:

The objective of the project work is to enable the students on a project involving theoretical and experimental studies related to the branch of study. Every project work shall have a guide who is the member of the faculty of the institution. Twenty four hours per week shall be allotted in the time table

and this time shall be utilized by the students to receive the directions from the guide, on library reading, laboratory work, computer analysis or field work as assigned by the guide and also to present in periodical seminars on the progress made in the project.

Each student will be assigned any one of the following types of project/thesis work:

(a) Industrial case study / Research Centre work report

(b) Preparation of a feasibility report

(c) Thesis by experimental research

(d) Design and development of equipment

Each report must contain student's own analysis or design presented in the approved format.

Sessional marks will include

(a) Evaluation of the student's progress

(b) Degree of involvement and participation

(c) Merit of the project

A student will have to defend his/her project/thesis and credit will be given on the merits of presentation and viva-voce examination.