Nanotechnology Division
Department of
Electronics and Communication Engineering

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PERIYAR MANIAMMAI INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University)
Established Under Sec. 3 of UGC Act, 1956 • NAAC Accredited
think • innovate • transform

Board of Studies in Nanotechnology Division / Department of ECE

Curriculum (I –IV Semesters)
&
Syllabus (I-IV Semesters)

(For the candidates admitted from 2018-19 onwards Based on Outcome Based Education)

For

M.Tech (Nanotechnology)

3 Year Degree Programme

APPROVED DATE	
BOS	28.05.2018
ACM	09.06.2018

VISION	To be a University of global dynamism with excellence in knowledge and innovation ensuring social responsibility for creating an egalitarian society.

MISSION	**UM1**	**Offering well balanced programmes with scholarly faculty and state-of-art facilities to impart high level of knowledge.**
	UM2	Providing student - centred education and foster their growth in critical thinking, creativity, entrepreneurship, problem solving and collaborative work.
	UM3	Involving progressive and meaningful research with concern for sustainable development.
	UM4	Enabling the students to acquire the skills for global competencies.
	UM5	Inculcating Universal values, Self respect, Gender equality, Dignity and Ethics.

CORE VALUES

- Student – centric vocation
- Academic excellence
- Social Justice, equity, equality, diversity, empowerment, sustainability
- Skills and use of technology for global competency.
- Continual improvement
- Leadership qualities.
- Societal needs
- Learning, a life – long process
- Team work
- Entrepreneurship for men and women
- Rural development
- Basic, Societal, and applied research on Energy, Environment, and Empowerment.

VISION	To be a pioneer division in offering Nanotechnology education and research with special emphasis on Energy, Environment and Health which would help to serve industry and society for developing cost effective and useful means

MISSION	DM1	To offer UG, PG and Research Programmes in Nano Technology
	DM2	To incorporate innovative teaching learning methods and teaching aids
	DM3	To nurture requirements of the emerging industrial needs to the students
	DM4	To cultivate the spirit of Entrepreneurship
	DM5	To explore solutions via Nano for the needs of society

Table: 1 Mapping of University Mission (UM) and Department Mission (DM)

	DM1	DM2	DM3	DM4	DM5	Total
UM1	3	2	2	2	2	11
UM2	2	2	2	2	2	10
UM3	2	2	2	2	2	10
UM4	2	1	1	1	1	6
UM5	1	0	1	0	0	2

1-Low 2- Medium 3 – High

PROGRAMME EDUCATIONAL OBJECTIVES

Based on the mission of the department, the programme educational objectives is formulated as

PEO1	Be employed in fields of engineering such as research, development, applications, testing, processing, analyzing and technical sales or service as an engineering technologist
PEO2	Start an entrepreneurial firm
PEO3	Achieve positions of increased responsibility (technical and/or supervisory) within an organization; and progress through advanced degree or certificate programs or participate in continuing education in engineering, business, and/or other professionally related fields.
PEO4	Progress through advanced degree or certificate programs or participate in continuing education in engineering, business, and/or other professionally related fields.

Mapping of Department Mission (DM) with Program Educational Objectives (PEOs)

	DM1	DM2	DM3	DM4	DM5
PEO1	3	2	1	1	2
PEO2	0	1	1	3	2
PEO3	1	-	2	-	-
PEO4	3	1	3	3	2
	7	4	7	7	6
	2	1	2	2	2

1 - Low Relation **2 - Medium Relation** **3 – High Relation**

GRADUATE ATTRIBUTES

1. **Engineering knowledge:** **Apply** the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation for the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling to complex engineering activities, with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM OUTCOMES

PO 1	**To strengthen the application of fundamental knowledge in Mathematics, Science, Engineering and Technology for the benefit of mankind.**
PO 2	**To enhance the technical competence of identifying, analyzing and creating appropriate engineering solutions.**
PO 3	To provide demand based training to meet the graduates readily employable by the industries.
PO 4	To create opportunities for the students to take on research projects for solving the problems of the future.
PO 5	To cultivate the habit of lifelong learning for successful career and life.
PO 6	To inculcate qualities of team work and leadership for creating future leaders of the nation.
PO 7	To impart awareness of social responsibilities for becoming a responsible citizen.
	PROGRAM SPECIFIC OUTCOME
PSO 1	Knowledge and generation of intellectual capital (Paper, poster, presentation, patent etc) in the areas of Nano architecture, Nanomaterials, Nanosystems, and their encompassing applications
PSO 2	Ability to identify tailor made Nano applications for Local and Societal needs by (a) Improving efficiency of existing systems by developing innovative low cost solutions (b) New product development

Mapping of Program Outcomes (POs) with Graduate Attributes (GAs)

PO/GA	GA 1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA 10	GA 11	GA 12
PO1	3	1	0	0	1	0	0	0	0	0	0	0
PO2	1	3	2	2	1	2	2	1	1	1	1	1
PO3	1	1	3	1	1	1	1	1	1	1	1	1
PO4	1	1	1	3	3	3	3	0	0	0	2	2
PO5	1	1	1	1	3	1	0	0	0	0	1	3
PO6	1	1	1	1	1	3	0	0	0	0	0	0
PO7	1	1	1	1	1	3	2	1	0	0	0	0
PSO1	2	2	2	2	2	2	2	1	1	2	2	2
PSO2	2	2	2	2	2	2	2	0	0	0	0	2

0-Relation 1- Low Relation 2 – Medium Relation 3-High Relation

Table 3 Mapping of Program Outcomes (POs) with Program Educational Objectives (PEOs)

PEO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
PEO 1	3	3	2	3	2	2	1	2	2
PEO 2	2	3	2	3	3	2	2	2	2
PEO 3	0	0	1	0	0	1	2	2	2
PEO 4	2	2	3	1	2	1	1	2	2

0-No Relation 1- Low Relation 2 – Medium Relation 3-High Relation

STRUCTURE OF M.TECH NANOTECHOLOGY PROGRAMME (FULLTIME)

S.No	Course Type	Symbol	Credits
1.	Professional core courses	PCC	12
2.	Professional Elective courses	PEC	15
3.	Open Elective Course	OEC	3
4.	Professional Core Courses –Lab	PCC-L	6
5.	Mandatory Courses	MC	2
6.	Audit	MC-Audit	0
7.	Project	PR	30
Total			**68**

PROFESSIONAL CORE COURSES (PCC)

Sl.No	Course Code	Course Name	Semester	Credits
1.	YNT101	Fundamentals of Nanotechnology	**I**	**3**
2.	YNT102	Nano Fabrication and Synthesis Techniques	**I**	**3**
3.	YNT201	Nanomaterials Characterization Techniques	**II**	**3**
4.	YNT202	Computational Nanotechnology	**II**	**3**

PROFESSIONAL ELECTIVE COURSES

Sl.No	Course Code	Course Name	Semester	Credits
1.	YNTE0 1	Societal Implications of Nanotechnology	I/II/III	3
2.	YNTE0 2	Nanomedicine	I/II/III	3
3.	YNTE0 3	Nanotechnology in Energy Conversion and Storage	I/II/III	3
4.	YNTE0 4	Nanoscale Magnetic Materials and Devices	I/II/III	3
5.	YNTE0 5	Metallopolymer Nanocomposites	I/II/III	3
6.	YNTE0 6	Nanotoxicology	I/II/III	3
7.	YNTE0 7	Green Manufacturing Technology	I/II/III	3
8.	YNTE0 8	Advanced Crystal Growth Techniques	I/II/III	3
9.	YNTE0 9	Carbon Nanotube Electronics and Devices	I/II/III	3

10.	YNTE10	Nanoscale Integrated Computing	I/II/III	3
11.	YNTE011	Micro/Nano Devices and Sensors	I/II/III	3
12.	YNTE12	Spectroscopic Techniques for Nanomaterials	I/II/III	3
13.	YNTE13	Nanochemistry	I/II/III	3
14.	YNTE14	Thin Film Science and Technology	I/II/III	3
15.	YNTE15	Micro and Nano Emulsions	I/II/III	3
16.	YNTE16	Nanotechnology Business Applications and Commercialization	I/II/III	3
17.	YNTE17	Nano – CMOS Circuit and Physical Design	I/II/III	3
18.	YNTE18	Properties of Nanophase Materials	I/II/III	3
19.	YNTE19	Nanomanipulation & Assembly	I/II/III	3

OPEN ELECTIVE COURSES

Sl.No	Course Code	Course Name	Semester	Credits
1.		Business Analytics	III	3
2.		Industrial Safety	III	3
3.		Operations Research	III	3
4.		Cost Management of Engineering Projects	III	3

PROFESSIONAL CORE COURSES – LAB

Sl.No	Course Code	Course Name	Semester	Credits
1.	YNT105	Simulation of Nanostructure & Nanomaterials Lab	I	2
2.	YNT106	Nano Fabrication and Synthesis Techniques Lab	I	2
3.	YNT205	Nanomaterials Characterization Techniques Lab	II	2
4.	YNT206	Computational Nanotechnology Lab	II	2
5.	YNT303	Dissertation Phase - I	III	10
6.	YNT401	Dissertation Phase - II	IV	16

MANDATORY COURSES

Sl.No	Course Code	Course Name	Semester	Credits
1.		Research Methodology and IPR	I	2
2.		Mini Project	II	2

MANDATORY COURSES - AUDIT

Sl.No	Course Code	Course Name	Semester	Credits
1.		English for Reasearch Paper Writing	I	0
2.		Constitution of India	II	0

CURRICULUM - REGULATION 2018

SEMESTER I

AICTE Abbr	Course Code	Course Title	Credits				Hours				
			L	**T**	**P**	**Total**	**L**	**T**	**P**	**S.S**	**Total**
PCC	YNT101	Fundamentals of Nanotechnology	3	0	0	3	3	0	0	0	3
PCC	YNT102	Nano Fabrication and Synthesis Techniques	3	0	0	3	3	0	0	0	3
PEC	YNT103*	Professional Elective Course I	3	0	0	3	3	0	0	1	4
PEC	YNT104*	Professional Elective Course II	3	0	0	3	3	0	0	1	4
PCC-L	YNT105	Simulation of Nanostructure & Nanomaterials Lab	0	0	2	2	0	0	4	0	4
PCC-L	YNT106	Nano Fabrication and Synthesis Techniques Lab	0	0	2	2	0	0	4	0	4
MC		Research Methodology and IPR	2	0	0	2	3	0	0	0	3
MC – Audit		English for Research Paper Writing	0	0	0	0	2	0	0	0	2
Total			**14**	**0**	**4**	**18**	**17**	**0**	**8**	**2**	**27**

Total Credits – 18

SEMESTER II

AICTE Abbr	Course Code	Course Title	Credits				Hours				
			L	**T**	**P**	**Total**	**L**	**T**	**P**	**S.S**	**Total**
PCC	YNT201	Nanomaterials Characterization Techniques	3	0	0	3	3	0	0	1	4
PCC	YNT202	Computational Nanotechnology	3	0	0	3	3	0	0	1	4
PEC	YNT203*	Professional Elective Course III	3	0	0	3	3	0	0	1	4
PEC	YNT204*	Professional Elective Course IV	3	0	0	3	3	0	0	0	3
PCC-L	YNT205	Nanomaterials Characterization Techniques Lab	0	0	2	2	0	0	4	0	4
PCC-L	YNT206	Computational Nanotechnology Lab	0	0	2	2	0	0	4	0	4
PR	YNT207	Mini Project	0	0	2	2	0	0	4	0	4
MC – Audit		Constitution of India	0	0	0	0	2	0	0	0	2
		Total	**12**	**0**	**6**	**18**	**14**	**0**	**12**	**3**	**29**

Total Credits – 18

SEMESTER III

AICTE Abbr	Course Code	Course Title	Credits				Hours				
			L	T	P	Total	L	T	P	S.S	Total
PCC	YNT301*	Professional Elective Course V	3	0	0	3	3	0	0	0	3
OE		Open Elective	3	0	0	3	3	0	0	0	3
PR	YNT303	Dissertation Phase - I	0	0	10	10	0	0	20	0	20
		Total	**6**	**0**	**10**	**16**	**6**	**0**	**20**	**0**	**26**

Total Credits – 16

SEMESTER IV

AICTE Abbr	Course code	Course Title	Credits				Hours				
			L	T	P	Total	L	T	P	S.S	Total
PR	YNT401	Dissertation Phase - II	0	0	0	16	0	0	32	0	32
		Total	0	0	0	16	0	0	32	0	32

Total Credits - 16

LIST OF PROFESSIONAL ELECTIVE COURSE

Course Code	Course Title	Credits				Hours				
		L	T	P	Total	L	T	P	S.S	Total
YNTE0 1	Societal Implications of Nanotechnology	3	0	0	3	3	0	0	0	3
YNTE0 2	Nanomedicine	3	0	0	3	3	0	0	0	3
YNTE0 3	Nanotechnology in Energy Conversion and Storage	3	0	0	3	3	0	0	0	3
YNTE0 4	Nanoscale Magnetic Materials and Devices	3	0	0	3	3	0	0	0	3
YNTE0 5	Metallopolymer Nanocomposites	3	0	0	3	3	0	0	0	3
YNTE0 6	Nanotoxicology	3	0	0	3	3	0	0	0	3
YNTE0 7	Green Manufacturing Technology	3	0	0	3	3	0	0	0	3

YNTE0 8	Advanced Crystal Growth Techniques	3	0	0	3	3	0	0	0	3
YNTE0 9	Carbon Nanotube Electronics and Devices	3	0	0	3	3	0	0	0	3
YNTE10	Nanoscale Integrated Computing	3	0	0	3	3	0	0	0	3
YNTE11	Micro/Nano Devices and Sensors	3	0	0	3	3	0	0	0	3
YNTE12	Spectroscopic Techniques for Nanomaterials	3	0	0	3	3	0	0	0	3
YNTE13	Nanochemistry	3	0	0	3	3	0	0	0	3
YNTE14	Thin Film Science and Technology	3	0	0	3	3	0	0	0	3
YNTE15	Micro and Nano Emulsions	3	0	0	3	3	0	0	0	3
YNTE16	Nanotechnology Business Applications and Commercialization	3	0	0	3	3	0	0	0	3
YNTE17	Nano – CMOS Circuit and Physical Design	3	0	0	3	3	0	0	0	3
YNTE18	Properties of Nanophase Materials	3	0	0	3	3	0	0	0	3
YNTE19	Computational Nanotechnology	3	0	0	3	3	0	0	0	3

LIST OF OPEN ELECTIVE COURSE

Course Code	**Course Title**	**Credits**				**Hours**				
		L	**T**	**P**	**Total**	**L**	**T**	**P**	**S.S**	**Total**
	Business Analytics	3	0	0	3	3	0	0	0	3
	Industrial Safety	3	0	0	3	3	0	0	0	3
	Operations Research	3	0	0	3	3	0	0	0	3
	Cost Management of Engineering Projects	3	0	0	3	3	0	0	0	3

Overall Credits – 68

SYLLABUS

SEMESTER I

COURSE CODE	**YNT101**	**L**	**T**	**P**	**C**
COURSE NAME	**FUNDAMENTALS OF NANOTECHNOLOGY**	**3**	**0**	**0**	**3**
PREREQUISITES	**APPLIED PHYSICS AND APPLIED CHEMISTRY**	**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**Emergence of Nanotechnology**	**9**

Historical Development: ancient works on Nanomaterials; emergence of nanotechnology with special reference to Feynman. Size & Scales: definition of nanostructures; insight into the nano world; intervention into the nano world; building blocks of nanotechnology. Scientific revolutions; types of nanotechnology & nano machines; basic problems & limitations; opportunities at the nanoscale; time and length scale in structures; energy landscapes.

UNIT II	**Nanoscale Phenomena**	**9**

Density of states; tunnelling; chemical bonds (types & strength). Intermolecular & inter-particle forces. Molecular & crystalline structures; particles & grain boundaries. Covalent & coulomb interactions; interactions involving polar molecules & polarization; weak intermolecular forces & total intermolecular pair potentials. Forces between solvation, hydration; polymers at surfaces; adhesion. Thermodynamics of self-assembly. Hierarchical structures & Functionality. Bulk to surface transition. Spatial & temporal scales; concept of confinement; role of surfaces in nanotechnology devices; surface reconstruction; dangling bonds & surface states; interfaces & Casmir force.

UNIT III	**Functional Nanomaterials**	**9**

Fullerenes, carbon nanotube, graphene. Monomers & polymers. Amorphous, crystalline, semi-crystalline; crystals, polycrystals. Composite materials; ceramics, alloys, silicates. Quantum hetero-structures: quantum well, quantum wire, quantum dot, nanofossils, smart dust, porous & nonporous inorganic materials, hydro gel & aerosols.

Bio nanomaterials: bio mimetic systems, bio ceramics, dendrimers, micelles, liposome’s, block copolymers. Nanomaterials for molecular electronics & optoelectronics: thin-film transistors, single-electron transistors, light-emitting devices, photovoltaic materials, nanomagnetic materials & nano superconductors.

UNIT IV	Structures of Nanomaterials	9

Crystal structure: crystal planes, Miller indices, crystal orientation. Morphology of materials, nanoparticles, nanowires, nanorods, nanoclusters, powders of nano crystalline materials, solid disordered nanostructures. Imperfection in solids: dislocations in single crystals (linear defects & screw dislocation) and imperfection-dependent properties of crystals.

UNIT V	Applications of Nanomaterials	9

Applications of nanomaterials in electronics & communication, healthcare, sensors, clothes, paints and other industrial as well as consumer products. Energy and Environmental applications. (This unit is aimed to provide an overview of various possible applications of nanomaterials).

LECTURE	TUTORIAL	PRACTICAL	TOTAL
45	0	0	45

TEXT

1. "Nanotechnology: Basic Science & Emerging Technologies," Mick Wilson, Kamali Kannangara & Geoff Smith, Overseas Press India Private Limited, 2005.
2. "Amorphous and Nanocrystalline Materials: Preparation, Properties and Applications," A. Inoue & K. Hashimoto (Eds.), Springer, 2001.3. "

E REFERENCES

1. http://nupex.eu/index.php?g=textcontent/materialuniverse/sizeofthings&lang=en
2. http://www.slideshare.net/niraliakabari3/ppt-of-phynanophysics
3. http://www.nanoscienceworks.org/publications/books/4/9781420048056/instructors/ITNS-Lecture-1.pdf
4. http://ipn2.epfl.ch/lns/lectures/nanoscience/lecturenotes/cour-1.pdf 5.
5. www.uniroma2.it/didattica/NANOSCIENZE/deposito/L1.ppt mp.misis.ru/docs/courses/17/Mats_Moscow_2.ppt 6.
6. http://uw.physics.wisc.edu/~himpsel/Nano/lectures.htm

E REFERENCES

www.nptel.ac.in

www.mit.co.in

COURSE CODE	**YNT102**	**L**	**T**	**P**	**C**
COURSE NAME	**NANO FABRICATION AND SYNTHESIS TECHNIQUES**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**Basic Concepts of Nano Fabrication**	**9**

Drexler-Smalley debate; realistic projections; outline of various preparation techniques; basic concepts of nano-structured materials; nucleation: surface nucleation, growth, grain size distribution; nano-particle transport in low density media; unnel nano phase thermodynamics; coagulation of nano particles; determination of grain size; aggregate formation; mass fractal morphologies. Requirements for an ideal semiconductor nano structure; clean room technology

UNIT II	**Physical Techniques**	**9**

Physical processes in semiconductor nano structures. Introduction; thin film deposition methods; fundamentals of film deposition; thermal evaporation; spray pyrolysis; flame pyrolysis; molecular beam epitaxy; pulsed laser deposition; sputter deposition; different types sputtering processes; thermal forming processes; plasma processes; physical methods for the preparation of nano tubes; types of nano tubes; new forms of carbon nano tubes; properties of nano tubes; plasma arcing; laser methods; pyrolytic synthesis; zeolites & template powders; layered silicates; soft chemical & combustion methods. Laser fusion target fabrication techniques; inorganic capsule fabrication; and cluster formation by laser ablation

UNIT III	**Chemical Methods**	**9**

Chemical unnel deposition (CVD); plasma-enhanced CVD; low pressure plasma CVD; metal-organic CVD (MOCVD); photo-enhanced CVD; electron enhanced CVD; Laser induced CVD; atmospheric pressure CVD; reactive ion etching (RIE) molecular-beam epitaxy (MBE); chemical beam epitaxy (CBE); chemical bath deposition; electrochemical synthesis of nano structures. Sol-gel processing; fundamentals of sol-gel process; sol-gel synthesis methods for oxides; other inorganics and nano composites; the Pecheni method; silica gel; zirconia and Yttrium gel; aluminosilicate gel; polymer nano composites. Mechanochemistry: grinding and milling devices

UNIT IV	**Self-Assembly**	**9**

Bottom-up approach. Self-assembly; self-assembled mono layers; directed assembly; layer-by-layer assembly; spontaneous formation & ordering of nano structures; nano-fluidics to build silicon devices with features comparable in size to DNA, proteins & other biological molecules; control and manipulation of microfluidic and nanofluidic processes for lab-on-a-chip devices. Langmuir Blodgett films; electrochemical self-assembly of oxide/dye composites. Self-assembled nanobiomaterials; pattern definition; pallsin transfer; atomic & molecular manipulation; biomineralization; colloidal quantum dots; self-assembly techniques

UNIT V	**Lithographic Techniques**	**9**

Top-down approach to nanolithography; immersion lithography, EUV photolithography; phase shifting masks; x-ray lithography, including plasma x-ray sources; e-beam and focused ion-beam lithography; photo resist technologies for the nano scale; metrology and defect inspection. Soft lithography; nano imprint lithography; wet etching, dry etching (isotropic, anisotropic), pattern growth techniques (polymerization, directed assembly). Proximal probe nano lithography; STM; AFM; resists & imaging layers for proximal probes

LECTURE	**TUTORIAL**	**PRACTICAL**	**TOTAL**
45	**0**	**0**	**45**

TEXT

1. "Introduction to Nanotechnology," Frank J. Owens & Charles P. Poole, Wiley-IEEE, 2003.
2. "Encyclopedia of Nanoscience & Nanotechnology," H. S. Nalwa, American Scientific Publishers, 2004.
3. "The Powder Method," L.V. Azaroff & M. J. Buerger, McGraw-Hill, 1958

REFERENCES

1."Introduction to Nanotechnology," Frank J. Owens & Charles P. Poole, Wiley-IEEE, 2003.

2. "Encyclopedia of Nanoscience & Nanotechnology," H. S. Nalwa, American Scientific Publishers, 2004.

2. "X-ray Diffraction Procedures," H. P. Klung & L. E. Alexander, John Wiley& Sons.

3. "The Powder Method," L.V. Azaroff & M. J. Buerger, McGraw-Hill, 1958

E REFERENCES

1. www.nptel.ac.in
2. www.mit.co.in

COURSE CODE	YNT105	L	T	P	C
COURSE NAME	**SIMULATION OF NANOSTRUCTURE & NANOMATERIALS LAB**	**0**	**0**	**2**	**2**
PREREQUISITES	Applied Physics , Applied Chemistry, Introduction to nanotechnology and Materials Science	**L**	**T**	**P**	**H**
		0	**0**	**4**	**4**

List of Experiments

1. Calculate the band structure of a crystal
2. Transport calculations with ATK
3. Phonon Band structure, Electrical and Heat Transport of a Graphene Nanoribbon
4. Electron-phonon coupling properties of a Graphene Nanoribbon
5. Optical Properties of Silicon
6. Study of $NiSi_2$–Si interface
7. Study of Bi_2Se_3 topological insulator
8. Study of Effective band structure of random alloy InGaAs
9. Study of Li-air battery interface
10. Study of Li-ion diffusion in $LiFePO_4$ for battery applications

		L	T	P	C
COURSE CODE	**YNT106**	**L**	**T**	**P**	**C**
COURSE NAME	**NANO FABRICATION AND SYNTHESIS TECHNIQUES LAB**	**0**	**0**	**2**	**2**
PREREQUISITES	Material Science , Nanofabrication Techniques and Introduction to nanotechnology	**L**	**T**	**P**	**H**
		0	**0**	**4**	**4**

List of Experiments

Any Twelve Experiments :

1. Synthesis of zno nanoparticles by Wet Chemical Precipitation
2. Synthesis of zero valent iron nanoparticles(fe^{3+}) by Wet Chemical Precipitation
3. Synthesis of Polymerosomes by Water Oil emulsification Technique
4. Synthesis of cadmium sulphide nanoparticles by Sol-Gel Method
5. Synthesis of pva/peg film by Spin Coating
6. ZnO thin film fabrication by Dip Coating Method
7. Synthesis of silver nanoparticles
8. Synthesis of zns nanoparticles
9. Fabrication of copper nanoparticles by Electrodeposition Techniques
10. Synthesis of cu/pva nanofibers by Electrospinning
11. Nanoarray Fabrication by Oxide Dot Fabrication
12. Synthesis of silver nanofibers
13. Herbal nanopowder fabrication by Ball Milling
14. Circuit fabrication by Manual Lithography Techniques
15. Thin film Fabrication by Spray Pyrolysis
16. Thin film fabrication By Physical Vapour Deposition
17. Nanopowder fabrication by Chemical Vapour Deposition

		L	T	P	C
COURSE CODE	**YNT201**	**L**	**T**	**P**	**C**
COURSE NAME	**NANOMATERIALS CHARACTERIZATION TECHNIQUES**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**Introduction to spectroscopy**	**9**

Basic principles and applications of UV-Vis-NIR, FTIR, FT-Raman, Photoluminescence, NMR, ESR and Light Scattering methods.

UNIT II	**X – ray techniques**	**9**

X-ray powder diffraction –Quantitative determination of phases; Structure analysis, single crystal diffraction techniques - Determination of accurate lattice parameters - structure analysis-profile analysis - particle size analysis using Scherer formula- Particle Size Analyzer- Ellipsometry- thickness measurements

UNIT III	**Electron Spectroscopy**	**9**

X-Ray Photoelectron Spectroscopy, Auger Electron Spectroscopy, X-Ray Characterization of Nanomaterials – EDAX and WDA analysis – EPMA - Applications to nanomaterials characterization

UNIT IV	**Mechanical, Magnetic and electrical properties measurement**	**9**

Nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions- models for interpretation of Nanoindentation loaddisplacement curves-Nanoindentation data analysis methods-Hardness testing of thin films and coatings- MD simulation of nanoindentation. Vibration Sample Magnetometer, Impedance Spectroscopy- PPMS, -Measurement of Magnetic and electrical properties of nanomaterials.

UNIT V	**Electrometric Methods of Analysis**	**9**

Types of electrochemical cells; electrode potentials.Hall measurement; Quantum Hall Measurement; Dynamic and static Current-Voltage (I-V) characteristics; capacitance; voltage measurements; I-V analysis by AFM and STM (STS); electron beam induced current measurement (EBIC)

	LECTURE	TUTORIAL	PRACTICAL	TOTAL
	45	**0**	**0**	**45**

TEXT

1. Skoog, Holler, Nieman " Principles of Instrumental Analysis"
2. Rainer Waser " Nanoscale Calibratin Standards"Wiley-VCH
3. Rainer Waser " Nanometrology"Wiley-VCH

REFERENCES

1. "Handbook of Nanostructured Materials and Nanotechnology," vols. 1-5, H. S. Nalwa (Ed.), Academic Press, 2000.
2. "Electron Microscopy and Analysis," P. J. Goodhews & F. J. Humphreys, Taylor and Francis.
3. "Modern Techniques of Surface Science," D. P. Woodruff & T. A. Delchar, Cambridge Solid State Science.
4. "Electronic Structure of Materials," A. P. Sutton, Oxford University Press, 1993.
5. "Semiconductor Materials & Device Characterization," D. K. Schroder, John Willy & Sons

E REFERENCES
1. www.nptel.ac.in **2.** www.mit.co.in

COURSE CODE	**YNT202**	**L**	**T**	**P**	**C**
COURSE NAME	**COMPUTATIONAL NANOTECHNOLOGY**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**Physical Modeling**	**9**

Basics of simulation and modeling - Role of simulation in model evaluation and studies - principles used in modeling - Concept of system and environment - continuous and discrete system - linear and nonlinear system - stochastic activities - static and dynamic models - Advantages and Disadvantages of simulation.

UNIT II	**Computation Based Simulation**	**9**

Technique of simulation - calumnious system models - experimental nature of simulation - numerical computation techniques - Monte Carlo method - analog and hybrid simulation - feedback systems.

UNIT III	**Probability Concepts in Simulation**	**9**

Stochastic variables - discrete and continuous probability functions - random numbers - generation of random numbers - variance reduction techniques - determination of the length of simulation runs - Output analysis.

UNIT IV	**Molecular Modeling**	**9**

Introduction to molecular modeling – molecular mechanics- molecular dynamics basic principles - Computing transport in materials - Simulation of crystals with chemical disorder at lattice sites – Design of compound semiconductor alloys using molecular simulations – Optical , electrical and structural property by first principle calculations.

UNIT V	**Micro and Nanostructure Modeling**	**9**

Studies on microstructure systems using atomistic and mesoscale simulations – Solid liquid phase transition under confinement – Modeling of metals - Simulation protocol – Semiemprical methods - Density functional theory mehods (DFT) - Visualization and analysis.

	LECTURE	**TUTORIAL**	**PRACTICAL**	**TOTAL**
	45	**0**	**0**	**45**

TEXT

1. Erwin Kreyzig, “Advanced Engineering Mathematics”, John Wiley & Sons, 2004

REFERENCES

1. Ramachandran K.I., G. Deepa, K.Namboori "Computational chemistry and molecular modeling – Principles and applications", Springer, 2008.
2. BeenaRai, "Molecular modeling for the design of Novel performance chemicals and materials", Taylor & Francis group, 2012.
3. Chistopher.J. Cramer "Essentials of Computational Chemistry- Theories and models". John wiley& sons 2004.

E REFERENCES

1. www.nptel.ac.in
2. www.mit.co.in

COURSE CODE	**YNT205**	**L**	**T**	**P**	**C**
COURSE NAME	**NANOMATERIALS CHARACTERIZATION TECHNIQUES**	**0**	**0**	**1**	**1**
PREREQUISITES	Applied Physics , Applied Chemistry, Introduction to nanotechnology and Materials Science	**L**	**T**	**P**	**H**
		0	**0**	**2**	**2**

List of Experiments

1. UV/VIS Spectroscopy and Spectrophotometry: Spectrophotometric Analysis of Potassium Permanganate Solutions.
2. Determination of Food Quality by UV Spectroscopic Methods.
3. Experimental studies on Thermal and Electrical properties of NiO2 thin film using SEM
4. Experimental setup for the measurement of the electrical resistivity and thermopower of thin films and bulk materials
5. Measuring Magnetization by Induction method
6. To determine the composition of a piece of tire tread using thermogravimetric analysis (TGA).
7. Analysis of the Thermal Properties of Ammonium Nitrate and Polystyrene by Differential Scanning Calorimetry (DSC)
8. Nanomechanical Measurements On Different Materials using Contact Mode AFM.

		L	T	P	C
COURSE CODE	**YNT206**	**L**	**T**	**P**	**C**
COURSE NAME	**COMPUTATIONAL NANOTECHNOLOGY**	**0**	**0**	**1**	**1**
PREREQUISITES		**L**	**T**	**P**	**H**
		0	**0**	**2**	**2**

List of Experiments

1. Simulation and modeling of simple molecular structures.
2. Prediction of crystals structure and properties using nanomaterials modeling methods.
3. Simulation and modeling of various nanostructures.
4. Simulation and modeling of metals nanoparticles and their studies.
5. Development of simulation protocols for the study of nanofilms and nanosurfaces.
6. Simulation and modeling study of nanomaterials and their optical property studies.
7. Simulation and modeling of nanomaterials and their electronic property studies.
8. Modeling of nanomaterials and their interaction studies with other molecules.

COURSE CODE	YNTE0 1	L	T	P	C
COURSE NAME	SOCIETAL IMPLICATIONS OF NANOTECHNOLOGY	3	0	0	3
PREREQUISITES		L	T	P	H
		3	0	0	3

UNIT I	Economic Impact of Nanotechnology	9

Socio-Economic Impact of Nanoscale Science - Managing the Nanotechnology Revolution: Consider the Malcolm Baldrige National Quality Criteria - The Emerging Nano Economy: Key Drivers, Challenges, and Opportunities -Transcending Moore's Law with Molecular Electronics and Nanotechnology -Semiconductor Scaling as a Model for Nanotechnology Commercialization - Sustaining the Impact of Nanotechnology on Productivity, Sustainability, and Equity

UNIT II	Social Scenarios	9

Navigating Nanotechnology Through Society - Nanotechnology, Surveillance, and Society: Methodological Issues and Innovations for Social Research - Nanotechnology: Societal Implications: Individual Perspectives -Nanotechnology and Social Trends - Five Nanotech Social Scenarios-Technological Revolutions and the Limits of Ethics in an Age of Commercialization - Vision, Innovation, and Policy

UNIT III	Converging Technology and Governance	9

Nanotechnology's Implications for the Quality of Life - Management of Innovation for Convergent Technologies -The "Integration/Penetration Model:" - The Use of Analogies for Interdisciplinary Research in the Convergence of Nano-, Bio-, and Information Technology - Converging Technologies: Innovation, Legal Risks, and Society .Governance- Problems of Governance of Nanotechnology -Institutional Impacts of Government Science Initiatives - Nanotechnology for National Security

UNIT IV	Ethics and Law	9

Ethics and Law - Ethical Issues in Nanoscience and Nanotechnology: Reflections and Suggestions - Ethics and Nano: A Survey - Law in a New Frontier - An Exploration of Patent Matters Associated with Nanotechnology -The Ethics of Ethics - Negotiations over Quality of Life in the Nanotechnology Initiative.

UNIT V	Public Perception and Participation	9

Public Interaction Research - Communicating Nanotechnological Risks - A Proposal to Advance Understanding of Nanotechnology's Social Impacts - Nanotechnology in the Media: A Preliminary Analysis - Public Engagement with Nanoscale Science and Engineering -

Nanotechnology: Moving Beyond Risk - Communication Streams and Nanotechnology: The (Re)Interpretationof a New Technology - Nanotechnology:Societal Implications — Individual Perspectives.

LECTURE	TUTORIAL	PRACTICAL	TOTAL
45	**0**	**0**	**45**

TEXT

1. Mihail C. Roco and William Sims Bainbridge ―Nanotechnology: Societal Implications II-Individual Perspectives‖, Springer (2007)

REFERENCES

1. Geoffrey Hunt and Michael D. Mehta ―Nanotechnology: Risk, Ethics and Law‖, Earthscan/James & James publication (2006).
2. Jurgen Schulte ―Nanotechnology: Global Strategies, Industry Trends and Applications‖, John Wiley & Sons Ltd (2005).
3. Mark. R. Weisner and Jean-Yves Bottero ―Environmental Nanotechnology applications and impact of nanomaterial‖, The McGraw-Hill Companies (2007).

E REFERENCES

1. www.nptel.ac.in
2. www.mit.co.in

COURSE CODE	**YNTE0 2**	**L**	**T**	**P**	**C**
COURSE NAME	**NANOMEDICINE**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**PROSPECT OF NANO-MEDICINE**	**9**

History of the idea – The Biological and Mechanical Traditions – Nano-medicine – Taxonomy – Bio-Pharmaceuticals – Implantable Materials – Implantable Devices – Surgical Aids – Diagnostic Tools – Genetic Testing – Imaging – Nanoparticles Probe – Case Analysis – 1) Resiprocytes – Mechanical Artificial Red Cells – 2) Using DNA as a construction medium

UNIT II	**NANOCARRIERS FOR DRUG DELIVERY**	**9**

Fundamentals and rationale of sustained / controlled/ targeted drug delivery – Factors influencing the design and performance of sustained release / controlled / targeted release products – Needs and Requirements of nanocarriers – Nanoparticle Flow: Implications for Drug Delivery – Polymeric Nanoparticles as Drug Carriers and Controlled Release Implant Devices.

UNIT III	**NANOPARTICULATE SYSTEMS FOR DRUG DELIVERY**	**9**

Polymer used for the formulation of controlled drug delivery systems – Classification and applications of polymers – Polymeric Micelles as Drug Carriers – Dendrimers as Nanoparticulate Drug Carriers – Nanocapsules preparation, Characterization and Therapeutic Applications

UNIT IV	**LIPID BASED NANOCARRIERS**	**9**

Liposomes for Genetic Vaccines and cancer therapy – Recent Advances in Microemulsions as Drug Delivery Vehicles – Lipoproteins as Pharmaceutical Carriers – Solid Lipid Nanoparticles as Drug Carriers – Lipidic core nanocapsules

UNIT V	**NANO CARRIERS AS DRUG TARGETING TOOLS**	**9**

Nanoparticulate Drug Delivery systems for the delivery of drugs to the Gastro-Intestinal Tract, Reticuloendothelial System, Cardiovascular System , lungs, Brain, and Lymphatic

LECTURE	TUTORIAL	PRACTICAL	TOTAL
45	**0**	**0**	**45**

TEXTBOOK

1. Parag D., and Ashish., "Nano Medicines", Pentagon Press, 2006.

2. Vladimir P.T., "Nanoparticulates as Drug Carriers", Imperial College Press, 2006
REFERENCES
1. Reza.A., Kentus. L., "Smart Nanoparticles in Nanomedicine ", Voume 8, Kentus Books, 2005
E REFERENCES
1. www.nptel.ac.in 2. www.mit.co.in

COURSE CODE	**YNTE03**	**L**	**T**	**P**	**C**
COURSE NAME	**NANOTECHNOLOGY IN ENERGY CONVERSION AND STORAGE**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**Introduction**	**9**

Nanotechnology for sustainable energy- Energy conversion process, indirect and direct energy conversion-Materials for light emitting diodes-batteries-advanced turbines-catalytic reactors-capacitors-fuel cells

UNIT II	**Renewable Energy Technology**	**9**

Energy challenges, development and implementation of renewable energy technologies - nanotechnology enabled renewable energy technologies -Energy transport, conversion and storage- Nano, micro, and poly crystalline and amorphous Si for solar cells, Nano-micro Si-composite structure, various techniques of Si deposition.

UNIT III	**Micro Fuel Cell Technology**	**9**

Micro-fuel cell technologies, integration and performance for micro -fuel cell systems -thin film and microfabrication methods - design methodologies - micro-fuel cell power source

UNIT IV	**Microfluidic Systems**	**9**

Nano-electromechanical systems and novel microfluidic devices - nano engines - drivingmechanisms - power generation - microchannel battery - micro heat engine (MHE) fabrication - thermocapillary forces -Thermocapillary pumping (TCP) - piezoelectric membrane

UNIT V	**Hydrogen Storage Methods**	**9**

Hydrogen storage methods - metal hydrides - size effects - hydrogen storage capacity -hydrogen reaction kinetics -carbon-free cycle- gravimetric and volumetric storage capacities - hydriding/dehydriding kinetics -high enthalpy of formation - and thermal management during the hydriding reaction.

LECTURE	**TUTORIAL**	**PRACTICAL**	**TOTAL**
45	**0**	**0**	**45**

TEXT

1. M.A. Kettani , Direct energy conversion, Addision Wesley Reading, (1970).
2. Linden , Hand book of Batteries and fuel cells, Mc Graw Hill, (1984).
3. Hoogers , Fuel cell technology handbook. CRC Press, (2003).
4. Vielstich, Handbook of fuel cells: Fuel cell technology and applications, Wiley, CRC Press, (2003)

REFERENCES

1. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, (1986).
2. Martin A Green, Solar cells: Operating principles, technology and system applications, Prentice Hall Inc,Englewood Cliffs, NJ, USA, (1981).
3. H J Moller, Semiconductor for solar cells, Artech House Inc, MA, USA, (1993).
4. Ben G Streetman, Solis state electronic device, Prentice Hall of India Pvt Ltd., New Delhi (1995)

E REFERENCES

1. www.nptel.ac.in
2. www.mit.co.in

COURSE CODE	**YNTE04**	**L**	**T**	**P**	**C**
COURSE NAME	**NANOSCALE MAGNETIC MATERIALS AND DEVICES**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**Introduction**	**9**

Magnetic fundamentals –Antiferromagnetic materials – Domains and the magnetization process – Coercivity of fine particles – Super paramagnetism in fine particles – Exchange anisotropy - Induced anisotropy in thin films –Electron transport in magnetic multi-layers – Spin polarized electron tunneling – Interlayer exchange coupling –Spin relaxation in magnetic metallic layers and multi-layers - Non-equilibrium spin dynamics in laterally defined magnetic structures

UNIT II	**Nanomagnetism**	**9**

Two-spin channel model - Two terminal spin electronics – Three terminal spin electronics - Spin tunneling - Study of ferromagnetic and antiferromagnet interfaces – Photoemission Electron Microscopy - X-ray Absorption Spectroscopy - X-ray Magnetic Linear Dichroism (XMLD) - X-ray Magnetic Circular Dichroism (XMCD) -Temperature dependence of X-ray Magnetic Dichroism.

UNIT III	**Fabrication and Imaging**	**9**

Molecular nanomagnets – Mesoscopic magnetism - Particulate nanomagnets – Geometrical nanomagnets –Fabrication techniques scaling – Characterization using various techniques – Imaging magnetic microspectroscopy –Optical Imaging – Lorentz Microscopy – Electron Holography of Magnetic Nanostructures –Magnetic Force Microscopy

UNIT IV	**Magnetic Data Storage and Recording**	**9**

Magnetic data storage – Disk formatting – Partitioning – Hard disk features – Hard disk data transfer modes –Programmed I/O – Direct memory access – Ultra DMA – Data addressing – Standard CHS addressing – Extended CHS addressing – Logical Block Addressing – Magnetic recording - Principles of magnetic recording - Magnetic digital recording - Perpendicular recording - Magneto-Optic recording - Magnetic media – Kerr effect – Faraday effect.

UNIT V	Magnetic Structures and Applications	9

Magnetic sensors and Giant Magnetoresistance - Optically transparent materials - Soft ferrites - Nanocomposite magnets - Magnetic refrigerant – High TC superconductor – Ferro/biofluids – Biomedical applications of magnetic nanoparticles - Diagnostic applications - Therapeutic applications - Physiological aspects - Toxic effects.

LECTURE	TUTORIAL	PRACTICAL	TOTAL
45	**0**	**0**	**45**

TEXT

1. Hans P.O., and Hopster H., ―Magnetic Microscopy of Nanostructures‖, Springer (2004)

REFERENCES

1. Bland J.A.C., and B. Heinrich.B., ―Ultra thin Magnetic Structures III – Fundamentals of Nanomagnetism‖, Springer (2004).
2. Nicola A.S., ―Magnetic Materials: Fundamentals and Device Applications‖, Cambridge University Press (2003).

E REFERENCES

1. www.nptel.ac.in
2. www.mit.co.in

COURSE CODE	**YNTE05**	**L**	**T**	**P**	**C**
COURSE NAME	**METALLOPOLYMER NANOCOMPOSITES**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**Nanoparticles In Materials Chemistry And In The Natural Sciences**	**9**

Classification of nanoparticles by size – Structural organization of nanoparticles – Dimensional phenomena in the chemistry and physics of nanoparticles – nanoparticles and materials on their base characteristic features of nanoparticles nucleat ion – Kinetic features of new phase formation – Phase formation in chemical reactions – Self organization of metal containing nanoparticles (Fractal structures) – Brief account of major production methods of metal containing nanoparticles – Metal clusters as nanoparticles with fixed dimensions.

UNIT II	**Principles and Mechanisms of Nanoparticle Stabilization by Polymers**	**9**

Stability of nanoparticles in solutions – Stabilizing capability characteristics of polymers – Characteristics of polymer absorption on metal surfaces specifics of polymer surfactants as stabilizers – Mechanism of nanoparticles stabilization by polymers – Stabilization of nanoparticles by electrolytes – Surface proofing as a method of stabilizing nanoparticles by polymers on the problem of matrix confinement

UNIT III	**Synthetic Methods for Metallo-Polymer**	**9**

Nanocomposite preparation – Physical methods of incorporating nanoparticles into polymers – Mechanochemical dispersion of precursors jointly with polymers – Microencapsulation of nanoparticles into polymers – Physical deposition of metal nanoparticles on polymers – Formation of 2D nanostructures on polymers – Formation of metal nanoparticles in polymer matrix voids (pores) – Physical modification and filling of polymers with metal reduction of polymer – Bound metal complexes – Nanocomposites formation by metal containing precursor thermolysis –Nanocomposite formation in monomer – Polymer matrices in thermolysis – Nanocomposites on the base of polymer – Immobilized metalloclusters

UNIT IV	**Physico-Chemical Methods for Metallo-Polymer Nanocomposite Production**	**9**

Cryochemical methods of atomic metal deposition on polymers – Metal evaporation methods on polymers localized at room temperature – Synthesis of nanocomposites in a plasma-chemical process – Radiolysis in polymer solutions – Photolysis of metal-polymer systems as means of

obtaining nanocomposites – Electrochemical methods of nanocomposite formation – General characteristics of sol-gel reactions – A combination of polymerization reactions and in situ sol-gel synthesis of nanocomposites – Sol-gel synthesis in the presence of polymers – Morphology and fractal model of Hybrid nanocomposites – Nanocomposites incorporating multi-metallic ceramics – Intercalation process – Polymerization into the basal space – Macromolecules introduction into the layered host lattices –Intercalation nanocomposites of polymer/metal chalcogenide type – Langmuir-Blodgett metallopolymers films as self organized hybrid nanocomposites.		
UNIT V	**Nanobiocomposites**	**9**
Basic notion of metal containing protein systems – Metal nanoparticles in Immunochemistry, Cytochemistry and Medicine – Biosorption, selective heterocoagulation and bacterial concentration of metal nanoparticles – Sol-gel process as a way of template – Synthesized nanobioceramics – Biomineralization and bioinorganic nanocomposites – Control of physic-mechanical properties of nanocomposites – Peculiarity of nanocomposites synthesized by solgel methods – Polyolefin based nanocomposites – Polymer matrix structurization in nanocomposites – Physical and mechanical properties of metallopolymer nanocomposites – Nanocomposites in adhesion compounds and Tribopolymers – New trends in Material science connected with metallopolymeric nanocomposites		

LECTURE	TUTORIAL	PRACTICAL	TOTAL
45	**0**	**0**	**45**

TEXT

1. C. F. Candau and R. H. Ottewill, ―An introduction to polymer colloids‖, Springer Berlin Heidelberg, New York, (2005)

REFERENCES

1. A. D. Pomogailo and V. S. Savostyanov, ―Synthesis and polymerization of metal containing monomers‖ CRC press, (1994).

E REFERENCES

1. www.nptel.ac.in
2. www.mit.co.in

COURSE CODE	**YNTE06**	**L**	**T**	**P**	**C**
COURSE NAME	**NANOTOXICOLOGY**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**Possible Health Impact of Nanomaterials**	**9**
Sources of Nanoparticles; Epidemiological Evidence; Entry Routes into the Human Body – Lung, Intestinal Tract, Skin; Nano particle Size - Surface and Body Distribution; Effect of Size and Surface Charges; Nanoparticles, Thrombosis and Lung Inflammation ;Nanoparticles and Cellular Uptake; Nanoparticles and the Blood-Brain Barrier		
UNIT II	**Nanomaterials for Environmental Remediation**	**9**
Introduction- Nanoparticle-based Remediation Materials - Acid-Base Chemistry - Redox Chemistry - Field Deployments of ZVI - Absorption Chemistry - Hybrid Nanostructured Remediation Materials - Self-assembled Monolayers on Mesoporous Supports (SAMMS) - Functional CNTs .		
UNIT III	**Biotoxicity of Metal Oxide Nanoparticles and Carbon Nanotubes**	**9**
Introduction; Nanoparticles in the Environment; Nanoparticles in Mammalian Systems; Health Threats; Nanomaterials and Biotoxicity; Iron Oxide; Titanium Dioxide; Dark Studies; UV Irradiation Studies;Other Metal Oxides; Toxicological Studies and Toxicity of Manufactured CNTs-case study; Toxicity of CNTs and Occupational Exposure Risk; Toxicity of MWCNTs/SWCNTs and Impact on Environmental Health		
UNIT IV	**Toxicology of Nanopartiles in Environmental Pollution**	**9**
Air Pollution; Introduction to Air Pollution Particles; Adverse Effects of PM in Epidemiological Studies; Role of Nanopartides in Mediating the Adverse Pulmonary Effects of PM; Effects of Nanopartides on the Cardiovascular System; Nanopartide Translocation and Direct Vascular Effects; Endothelial Dysfunction and Endogenous Fibrinolysis; Coagulation and Thrombosis; Cardiac Autonomie Dysfunction; Effects of Nanopartides on the Liver and Gastrointestinal Tract; Effects of NP on the Nervous System.		

UNIT V	Dosimetry, Epidemiology and Toxicology of Nanoparticles			9
Epidemiological Evidence for Health Effect Associations with Ambient Particulate Matter; Toxicological Evidence for Ambient Particulate Matter Induced Adverse Health Effects; Inhaled Nanoparticle Dosimetry; Toxicological Plausibility of Health Effects Caused by Nanoparticles; Integrated Concept of Risk Assessment of Nanoparticles				
LECTURE	**TUTORIAL**	**PRACTICAL**	**TOTAL**	
45	**0**	**0**	**45**	

TEXT

1. Challa S. S. R. Kumar, ―Nanomaterials - Toxicity, Health and Environmental Issues‖, Wiley-VCH publisher (2006).
2. Nancy A. Monteiro-Riviere, C. Lang Tran, ―Nanotoxicology: Characterization, Dosing and Health Effects‖, Informa healthcare (2007)

REFERENCES

1. D. Drobne, ―Nanotoxicology for safe and Sustainable Nanotechnology‖, Dominant publisher (2007).
2. M. Zafar Nyamadzi, ―A Reference handbook of nanotoxicology‖, Dominant publisher (2008).

E REFERENCES

www.nptel.ac.in

www.mit.co.in

COURSE CODE	**YNTE07**	**L**	**T**	**P**	**C**
COURSE NAME	**GREEN MANUFACTURING TECHNOLOGY**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**Green Manufacturing Trends**	**9**

Green Manufacturing: Fundamentals and Applications - basic definitions and issues surrounding green manufacturing at the process, machine and system - government motivations for green manufacturing - traditional manufacturing to green manufacturing -economic issues-surrounding green manufacturing - the areas of automotive, semiconductor and medical areas as well as in the supply chain and packaging areas Green Manufacturing.

UNIT II	**Sustainable Green Manufacturing**	**9**

Introduction - sustainable green manufacturing -green manufacturing sustainability processes, requirements, and risk - The sustainable lean and green audit process. International green manufacturing standards and compliance. Green rapid prototyping and rapid manufacturing. Green flexible automation. Green collaboration processes . Alternative energy resources. Globally green manufacturing supply chains and logistic networks. Sustainable green manufacturing system design.

UNIT III	**Waste Management**	**9**

Sustainability and global conditions - Material and solid waste management - Energy management -chemical waste management and green chemistry - Climate change and air emissions management - Supply water and waste water management - Environmental business management

UNIT IV	**Industrial Ecology**	**9**

Introduction-Material flows in chemical manufacturing-Industrial parks-Assessing opportunities for waste exchanges and by product synergies-Life cycle concepts-Product shewardship and green engineering-Regulatory, social and business environment for green manufacturing.-Metrics and analytical tools.- Green supply chains.-Present state of green manufacturing.

UNIT V	**Green Plastics Manufacturing**	**9**

Introduction to commercial plastics and elastomers -Natural Rubber (NR), modified NR and blends -

Polyesters from microbial and plant biofactories (polylactic acid and poly hyroxyalkanoates) - Plastics from vegetable oils -Cellulose and starch based materials -Natural fillers, fibers, reinforcements and clay nanocomposites -Biodegradability, life cycle assessment and economics of using natural materials.

LECTURE	TUTORIAL	PRACTICAL	TOTAL
45	**0**	**0**	**45**

TEXT

1. T. David Allen and David R. Shonnard, Green engineering, Prentice Hall NJ, (2002).
2. David Dornfeld, Green manufacturing fundamental and applications, Prentice hall (2002).
3. G. Sammy Shinga, Green electronics design and manufacturing, Prince publications, (2008).
4. James clark, Green chemistry, Blackwell publishing (2008)

REFERENCES

1. Paulo Davim, Sustainable Manufacturing, Wiley publications (2010).
2. Frank Kreith, George Tchobanoglous, Solid waste management, McGraw Hill (2002).
3. E. S. Stevens, Green plastics, Princeton university press (2002).
4. U. Robert Ayres, A Handbook of Industrial Ecology, Edward elgar publishing (2002).

E REFERENCES

1. www.nptel.ac.in
2. www.mit.co.in

COURSE CODE	**YNTE08**	**L**	**T**	**P**	**C**
COURSE NAME	**ADVANCED CRYSTAL GROWTH TECHNIQUES**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**Crystal Growth Theory**	**9**
Introduction – Nucleation – Gibbs – Thomson equation for melt and solution – kinetic theory of nucleation –Limitation of classical nucleation – Rate of nucleation – Different shapes of nucleus – spherical, cap shaped and cylindrical.		
UNIT II	**Growth from Melt**	**9**
Bridgeman method – Kyropolous method – Czochralski method – Verneuil method – Zone melting method. Growth from flux – Slow cooling method – Temperature difference method – High pressure method – Solvent evaporation method – Top seeded solution growth		
UNIT III	**Growth from Vapor Phase**	**9**
Physical vapor deposition – Chemical vapor transport – Open and Closed system – Thermodynamics of chemical vapor deposition process – Physical and Thermo-chemical factors affecting growth process.		
UNIT IV	**Growth from Solutions**	**9**
Solvent and solutions – Solubility – Preparation of a solution – Saturation and supersaturation – Measurement of supersaturation – Expression for supersaturation – Low temperature growth solution growth – Slow cooling method – Manson jar method – Evaporation method – Temperature gradient method – Electro crystallization.Growth from gels – Experimental methods – Chemical reaction method – Reduction method – Complex decomposition method – Solubility reduction method – Growth by hydrothermal method.		
UNIT V	**EPITAXY**	**9**
Vapor phase epitaxy – Liquid phase epitaxy – Molecular beam epitaxy – Atomic layer epitaxy – Electro-epitaxy – Metalorganic vapor phase epitaxy – Chemical beam epitaxy.		

LECTURE	TUTORIAL	PRACTICAL	TOTAL
45	**0**	**0**	**45**

TEXT

1. Sangwal. K., ―Elementary Crystal Growth‖ 1st Ed., Saan Publisher, UK, (1994).
2. Faktor. M. M. and Garet. I., ―Growth of crystal from vapor‖ 1st Ed., Chapmann and Hall, (1988).
3. Santhana Ragavan. P. and Ramasamy. P., ―Crystal growth and process‖, 1st Ed., KRU Publications, (2000).

REFERENCES

1. Ramasamy. P., ISTE Summer School Lecture Notes, ―Crystal Growth Centre‖, Anna University, Chennai, (1991).
2. Brice, J. C., ―Crystal growth process‖, 1st Ed., John Wiley Publications, New York, (1986).
3. Chernov. A. A., ―Modern Crystallography: III – Crystal Growth‖, 1st Ed., Springer series in Solid State, New York, (1984)

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COURSE CODE	**YNTE09**	**L**	**T**	**P**	**C**
COURSE NAME	**CARBON NANOTUBE ELECTRONICS AND DEVICES**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**Basics of Carbon Nanotubes**	**9**
Carbon materials – Allotropes of carbon – Structure of carbon nanotubes – Types of CNTs – Electronic properties of CNTs – Band structure of Graphene – Band structure of SWNT from graphene – Electron transport properties of SWNTs – Scattering in SWNTs – Carrier mobility in SWNTs.		
UNIT II	**Synthesis and Integration of SWNT Devices**	**9**
Introduction – CVD synthesis – Method – Direct incorporation with device fabrication process – SWNT synthesis on metal electrodes – Lowering the synthesis temperature – Controlling the SWNT growth – Location, Orientation, Chirality – Narrowing diameter distributions – Chirality distribution analysis for different CVD processes – Selective removal of the metallic nanotubes in FET devices – Integration		
UNIT III	**Carbon Nanotube Field-Effect Transistors**	**9**
Schottky barrier heights of metal S/D contacts – High k-gate dielectric integration – Quantum capacitance – Chemical doping – Hysteresis and device passivation – Near ideal, Metal-contaced MOSFETs – SWNT MOSFETs – SWNT band-to-band tunnelling FETs		
UNIT IV	**AC Response and Device Simulation Of Swnt Fets**	**9**
Assessing the AC response of Top gated SWNT FETs – Power measurement using a spectrum analyzer –Homodyne detection using SWNT FETs – RF characterization using a two tone measurement – AC gain from a SWNT FET common source amplifier – Device simulation of SWNT FETs – SWNT FET simulation using NEGF – Device characteristics at the Ballistic limit – Role of Phonon scattering – High frequency performance limits – Optoelectronic phenomena.		
UNIT V	**Carbon Nanotube Device Modeling and Circuit Simulation**	**9**
Schottky barrier SWNT-FET modeling – Compact model for circuit simulation – Model of the intrinsic SWNT channel region – Full SWNT-FET model – Applications of the SWNT-FET compact model – Performance modeling for carbon nanotube interconnects – Circuit models		

for SWNTs – Circuit models for SWNT bundles – Circuit models for MWNTs – Carbon nanotube interconnects – Applications.			
LECTURE	**TUTORIAL**	**PRACTICAL**	**TOTAL**
45	**0**	**0**	**45**

TEXT

1. Ali Javey and Jing Kong, ―Carbon Nanotube Electronics‖ Springer Science media, (2009).
2. Michael J. O'Connell, ―Carbon nanotubes: Properties and Applications‖, CRC/Taylor & Francis, (2006).

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1. Francois Leonard, ―The Physics of Carbon Nanotube Devices‖, William Andrew Inc., (2009).
2. R. Saito and M. S. Drbselmus, ―Physical properties of Carbon Nanotubes‖ Imperial College Press, (1998).

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COURSE CODE	**YNTE10**	**L**	**T**	**P**	**C**
COURSE NAME	**NANOSCALE INTEGRATED COMPUTING**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**An Introduction to Nanocomputing**	**9**
Micro computing era – Transistor as a switch, difficulties with transistors at the nanometer scale – Nanoscale devices – Molecular devices – Nanotubes – Quantum dots – Wave computing – Quantum computing.		
UNIT II	**Quantum Computing**	**9**
Reversible computations – Quantum computing models – Complexity bounds for quantum computing – Quantum compression – Quantum error correcting codes – Quantum cryptography – Computing with quantum dot cellular automata – Quantum dot cellular automata cell – Ground state computing – Clocking – QCA addition – QCA multiplication – QCA memory – 4-bit processor		
UNIT III	**Spin-Wave Architectures**	**9**
Spin wave crossbar – Spin wave reconfigurable mesh – Spin wave fully interconnected cluster – Multi-scale Hierarchical architecture – Spin wave based logic devices – Logic functionality – Parallel computing with spin waves – Parallel algorithm design techniques – Parallel routing and broadcasting – On-Spin wave crossbar – OnSpin wave reconfigurable mesh – On-Spin wave fully interconnected cluster		
UNIT IV	**Molecular Computing**	**9**
Switching and memory in molecular bundles – molecular bundle switches – Circuit and architectures in molecular computing – Molecular grafting for silicon computing – Molecular grafting on intrinsic silicon nanowires – Self assembly of CNTs		
UNIT V	**Computational Tasks In Medical Nanorobotics**	**9**
Medical Nanorobot designs – Microbivores – Clottocytes – Chromallocytes – Common functions requiring onboard computation – Nanorobot control protocols: Operation protocols – Biocompatibility protocols – Theater protocols –Nanoscale image processing: Labeling problem – Convex Hull problem – Nearest neighbor problem		

LECTURE	TUTORIAL	PRACTICAL	TOTAL
45	**0**	**0**	**45**

TEXT
1.Nielsen M. A. and Isaac L. Chuang, ―Quantum computation and quantum information‖, Cambridge University ,Press, (2000). 2.Jain A. K., ―Fundamentals of Digital Image Processing‖, Prentice-Hall, (1988)
REFERENCES
1. Schroder D. K., ―Semiconductor Material and Device Characterization‖, New York, (2006). 2. Zhou C. and New Haven, ―Atomic and Molecular wires‖, Yale University Press, (1999).
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1. www.nptel.ac.in 2. www.mit.co.in

<table>
<tr><td>COURSE CODE</td><td colspan="2">YNTE11</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>COURSE NAME</td><td colspan="2">MICRO / NANO DEVICES AND SENSORS</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>PREREQUISITES</td><td colspan="2"></td><td>L</td><td>T</td><td>P</td><td>H</td></tr>
<tr><td colspan="3"></td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>UNIT I</td><td colspan="5">Introduction</td><td>9</td></tr>
<tr><td colspan="7">MEMS and NEMS definitions, Taxonomy of Nano-and Microsystems-Synthesis and Design. Classification and considerations, Biomimetics, Biological analogies, and design–Biomimetics Fundamentals, Biomimetics for NEMS and MEMS, Nano-ICs and Nanocomputer architectures.</td></tr>
<tr><td>UNIT II</td><td colspan="5">Modeling of Micro And Nano Scale Electromechanical Systems</td><td>9</td></tr>
<tr><td colspan="7">Introduction to modeling, analysis and simulation, basic electro -magnetic with application to MEMS and NEMS, modeling developments of micro-and nano actuators using electromagnetic-Lumped-parameter mathematical models of MEMS, energy conversion in NEMS and MEMS.</td></tr>
<tr><td>UNIT III</td><td colspan="5">Inorganic and Organic Enabled Sensors</td><td>9</td></tr>
<tr><td colspan="7">Introduction-types of sensors-Mechanical, optical, spintronic, bioelectronic and biomagnetic sensors-surface modification-surface materials and interactions and its examples</td></tr>
<tr><td>UNIT IV</td><td colspan="5">Sensor Characteristics and Physical Effects</td><td>9</td></tr>
<tr><td colspan="7">Introduction to sensors, static Characteristics and dynamic characteristics, Physical effects : - Photoelectric Effect, Photoluminescence Effect, Electroluminescence Effect , Chemiluminescence Effect, Doppler Effect , Hall Effect, thermoelectric effect, magneto-optical phenomena</td></tr>
<tr><td>UNIT V</td><td colspan="5">Future Nanosystems</td><td>9</td></tr>
<tr><td colspan="7">Nano machines, nano robots, electronics based on CNT, molecular Electronics. Quantum Computation: Future of Meso/Nanoelectronics? -Interfacing with the Brain, towards molecular medicine, Lab-on-BioChips- Guided evolution for challenges and the solutions in NanoManufacturing technology</td></tr>
<tr><td colspan="2">LECTURE</td><td>TUTORIAL</td><td colspan="2">PRACTICAL</td><td colspan="2">TOTAL</td></tr>
<tr><td colspan="2">45</td><td>0</td><td colspan="2">0</td><td colspan="2">45</td></tr>
<tr><td colspan="7">TEXT</td></tr>
<tr><td colspan="7">1. Sergey Edward Lyshevski, Lyshevski Edward Lyshevski, Micro-Electro Mechanical and Nano-Electro Mechanical Systems, Fundamental of Nano-and Micro-Engineering – 2nd Ed.,CRC Press, (2005).
2. A.S.Edelstein and Cammarata, Nanomaterials: Synthesis, Properties and Applications</td></tr>
</table>

Institute of Physics,Bristol, Philadelphia: Institute of Physics, (2002).

3. N. P. Mahalik, Micro manufacturing and Nanotechnology, Springer Berlin Heidelberg New York (2006).

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1. Mark J. Jackson, Micro and Nanomanufacturing, (2007).
2. Zheng Cui, Nanofabrication, Principles, Capabilities and Limits, (2008).
3. Kalantar–Zadeh K, Nanotechnology Enabled Sensors, Springer, (2008).
4. Serge Luryi, Jimmy Xu, Alex Zaslavsky, Future trends in MicroElectronics, John Wiley & Sons, Inc. Hoboken, New Jersey (2007).

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COURSE CODE	**YNTE12**	**L**	**T**	**P**	**C**
COURSE NAME	**SPECTROSCOPIC TECHNIQUES FOR NANOMATERIALS**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**Nano Optics**	**9**

Basic Concepts-Spontaneous Emission- Classical Bound- Radiating Electron-Quantum Mechanical Radiative Decay-Absorption and Emission - Absorption Coefficient and Absorption Cross-Section,Absorption and Induced Emission-Nano-optics and local spectroscopy - Scanning plasmon near-field optical spectroscopy (SPNM)-near-field optical spectroscopy- nearfield nonlinear optics

UNIT II	**Molecular Spectroscopies Of Nanoassemblies**	**9**

Simplified model for vibrational interactions-Characteristic bands for organic compounds - Attenuated-total reflection (ATR) and grazing incidence angle techniques-Reflection-absorption IR spectroscopy (RAIRS)-The Raman Effect- Lateral and in-depth Resolution of Conventional μRS- Resonant Raman Spectroscopy (RRS) - Nanospecific Modes- Surface-Enhanced Raman Spectroscopy (SERS)- Nano-Raman- Phase Identification and Phase Transitions in Nanoparticles- Characterizing Carbon Materials with Raman Spectroscopy

UNIT III	**Nonlinear Spectroscopies**	**9**

Absorption saturation and harmonic generation,Second-harmonic generation (SHG) and sum frequency spectroscopy (SFG)- Luminescence up conversion-The use of nonlinear optical methods to obtain infrared spectra of ultra-thin assemblies confined to surfaces

UNIT IV	**Luminescence Spectroscopies**	**9**

Optical properties of assembled nanostructures-interaction between nanoparticles-Direct and indirect gap transitions-, -Single molecule and single nanoparticles spectroscopy-Dynamic light scattering spectroscopy Fluorimetry and chemiluminescence - X-ray fluorescence spectrometry-Atomic emission spectroscopy.

UNIT V	**Electron Spectroscopies for Nanomaterials**	**9**

X-Ray Beam Effects,Spectral Analysis -Core Level Splitting Linewidths- Elemental Analysis:

Qualitative and Quantitative -Secondary Structure ,XPS Imaging -Angle-Resolved - Basic Principles of AES-Instrumentation Experimental Procedures Including Sample Preparation - AES Modifications and Combinations with other Techniques -Auger Spectra: Direct and Derivative Forms and Applications-Electron energy loss spectroscopy of nanomaterial

LECTURE	TUTORIAL	PRACTICAL	TOTAL
45	**0**	**0**	**45**

TEXT

1. Vladimir G. Bordo and Horst-Günter Rubahn; ―Optics and Spectroscopy at Surfaces and Interfaces" John-Wiley and Sons, Inc., (2005).
2. William W. Parson, Modern Optical Spectroscopy, Springer, (2007).
3. Collin Banwell, Mc Cash, Fundamentals of Molecular Spectroscopy, McGraw Hill (1994).
4. Harvey Elliot White, Introduction to Atomic Spectra, McGraw Hill, (1934).

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1. Francis Rouessac and Annick Rouessac, Chemical Analysis-Modern Instrumentation Methods and Techniques,(2000)
2. Joseph. R. Lakowicz Principles of fluorescence spectroscopy, Springer, (2010).
3. Pavia, Lampman, Kriz, Vyvyan, Introduction to spectroscopy, Cengage learning, (2009).
4. Jin Jhong Jhang, Optical properties and spectroscopies of Nanomaterials, World Scientific Publishing (2009).

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		L	T	P	C
COURSE CODE	**YNTE13**	**L**	**T**	**P**	**C**
COURSE NAME	**NANOCHEMISTRY**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**CHEMISTRY OF NANOPARTICLES**	**9**
Synthesis by Organic Molecule Templates – Molecular Self-Assembly – Spatially Constrained Synthesis - Biomimetic Synthesis – Oxide Nanoparticles – Particle size – Particle shape – Particle density – Composite structure – Pore structure – Surface modification of inorganic Nanoparticles by organic functional groups		
UNIT II	**ADVANCED POLYMERIC MATERIALS**	**9**
Polymer chain statistics – Static light scattering – Hydrodynamics of polymer solutions – Thermodynamics of polymer solutions – Polymer blends – Solubility parameters and group contribution methods – High performance thermoplastics – Polymer material for photovoltaic applications – Synthetic biomedical polymers – Optical fibers – Assembly of polymer – Nanoparticle composite material – Fabrication of polymer – Applications of polymers in catalysis.		
UNIT III	**SUPRAMOLECULAR CHEMISTRY**	**9**
Dendrimers and their applications – From molecular to supramolecular Chemistry, Molecular Recognition, Anionic Coordination Chemistry and Recognition of Anionic Substrates, Multiple Recognition Applications.		
UNIT IV	**NANOCATALYSIS**	**9**
Types of catalysis – Homogeneous, heterogeneous and biocatalysis – Catalysis by nanoparticles – Physical properties of free and supported nanoparticles – Reactivity of supported metal nanoparticles – Gold nanoparticles – Preparative methods and properties – Reactions – Water gas shift – vinyl acetate synthesis – hydrogenation – CO oxidation – Heck reaction – Commercial application.		
UNIT V	**ELECTROCHEMISTRY OF NANOMATERIALS**	**9**
Electrochemistry of Semiconductor Nanostructures, Nanostructured Metal Oxide Films. Electrochemistry with Nanoparticles – Preparation of Nanostructures, Electrochemistry with Metallic Nanoparticles – Monolayer protected nanoclusters, Nanoelectrode Ensembles, Single Electron Events, Probing Nanoparticles using Electrochemistry Coupled with Spectroscopy –		

Nanosensors –Biosensors – Chemical Sensors –Electrocatalysis.

LECTURE	TUTORIAL	PRACTICAL	TOTAL
45	**0**	**0**	**45**

TEXT

1. Hosokawa.M., Nogi.K., Naito.M. Y., "Nanoparticle Technology Handbook" Vol. I, Elsevier, 2007
2. Pignataro.B., "Tomorrow's Chemistry Today, Concepts in Nanoscience, Organic Materials and Environmental Chemistry", Wiley-Vch Verlag GmbH, 2008.

REFERENCES

1. Carraher.C. E., Seymour . R. B., "Polymer Chemistry", CRC / Taylor and Francis, 2008
2. Rao. C. N. R., Mu¨ller.A., Cheetham.A. K., "The Chemistry of Nanomaterials: Synthesis, Properties and Applications", Wiley-Vch Verlag GmbH, 2004
3. Ozin.G.A., Aresenault.A.C., "Nanochemistry: A Chemical Approach to Nanomaterials", RSC Publishing, 2005.
4. Br´echignac.C ., Houdy.P., Lahmani. M., "Nanomaterials and Nanochemistry", Springer-Verlag, 2007

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COURSE CODE	**YNTE14**	**L**	**T**	**P**	**C**
COURSE NAME	**THIN FILM SCIENCE AND TECHNOLOGY**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**Thin Film Deposition Techniques**	**9**
Introduction – Kinetic theory of gases - Physical vapour deposition techniques – Physics and Chemistry of Evaporation - Thermal evaporation – Pulsed laser deposition – Molecular beam epitaxy – Sputtering deposition –DC, RF, Magnetron, Ion beam and reactive sputtering - Chemical methods – Thermal CVD – Plasma enhanced CVD – Spray Pyrolysis – Sol Gel method – Spin and Dip coating – Electro plating and Electroless plating –Deposition mechanisms.		
UNIT II	**Characterization Techniques**	**9**
Surface analysis techniques – Auger Electron spectroscopy – Photoelectron Spectroscopy – Secondary Ion Mass Spectroscopy – X-ray Energy Dispersive Analysis – Rutherford Backscattering spectroscopy - Imaging Analysis Techniques – Scanning Electron Microscopy – Transmission Electron Microscopy – Optical analysis Techniques –Ellipsometry – Fourier Transform Infrared Spectroscopy – Photoluminescence Spectroscopy		
UNIT III	**Adsorption And Diffusion In Thin Films**	**9**
Physisorption – Chemisorption – Work function changes induced by adsorbates – Two dimensional phase transititions in adsorbate layers – Adsorption kinetics – Desorption techniques. Fundamentals of diffusion –Grain Boundary Diffusion – Thin Film Diffusion Couples - Inter Diffusion -Electromigration in thin films – Diffusion during film growth		
UNIT IV	**Stress in Thin Films**	**9**
Origin of Thin film stress - Classifications of stress – Stress in epitaxial films – Growth Stress in polycrystalline films – Correlation between film stress and grain structure – Mechanisms of stress evolution – film stress and substrate curvature – Stoney formula – Methods of curvature measurement – Scanning laser method		
UNIT V	**Modification of Surfaces And Films**	**9**
Introduction – Laser and their Interactions with Surfaces – Laser modification effects and applications – Laser sources and Laser scanning methods - Thermal analysis of Laser		

annealing - Laser surface alloying - Ion implantation effects in solids – Energy loss and structural modification – compositional modification - Ion beam modification phenomena and applications

LECTURE	TUTORIAL	PRACTICAL	TOTAL
45	**0**	**0**	**45**

TEXT

1. Amy E. Wendt, Thin Films - High density Plasmas, Volume 27, Springer Publishers. (2006).
2. Rointan F. Bunshah, Hand Book of Deposition technologies for Thin Films and coatings by Science, Technology and Applications ,Second Edition , Noyes Publications, (1993).
3. Milton Ohring, Materials Science of Thin films Published by Academic Press Limited(1991)

REFERENCES

1. L.B. Freund and S.Suresh, Thin Film Materials, (2003). L.B. Freund and S.Suresh, Thin Film Materials, (2003).

2. Hans Luth, Solid surfaces, Interfaces and Thin Films' 4th edition, Springer Publishers (2010).

3. Harald Ibach, Physics of Surfaces and Interfaces, Springer Publishers (2006).AM

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COURSE CODE	**YNTE15**	**L**	**T**	**P**	**C**
COURSE NAME	**MICRO AND NANO EMULSIONS**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**Introduction**	**9**

Definition of nano- and micro- emulsions – Reason for their long term kinetic stability – Practical application in personal care products and cosmetics, healthcare products, pharmaceuticals and agrochemicals – Schematic representation of oil/water and water/oil emulsions – Comparison with micelles and macroemulsions – Methods of emulsification: Pipe flow, static mixers and general stirrers, high-speed mixers, colloid mills and high pressure homogenizers – continuous and batch-wise preparations – turbulent flow.

UNIT II	**Mechanism of Emulsification**	**9**

Role of interfacial energy – Explanation of the high energy required for formation of nanoemulsions – The Laplace pressure concept – Role of surfactants: Reduction in interfacial tension and the effect on dro plet size – Gibbs adsorption equation – Interfacial dilational modulus and droplet deformation – Interfacial tension gradients and the Marangoni effect - Solubilization theories: Concept of a duplex film and bending of the interface to form o/w or w/o emulsions – Phase diagrams of ternary systems of water, surfactant and cosurfactant – Concept of normal and inverse micelles – Quarternary phase diagrams of oil/water surfactant and cosurfactant – Solubilization of oil by nonionic surfactant

UNIT III	**Formulation of Emulsion**	**9**

High pressure homogenization and efficiency of preparation – The Phase Inversion Temperature (PIT) principle –Variation of interfacial tension with temperature – Phase diagrams as a function of temperature – Formulation of microemulsions – Selection of microemulsions: Hydrophilic Lipophilic Balance (HLB) concept – Phase Inversion Temperature (PIT) concept – Cohesive Energy Ratio (CER) concept

UNIT IV	Characterization of Emulsions	9
Scattering techniques: Time average light scattering – Neutron scattering – Quasi-elastic light scattering (Photon Correlation Spectroscopy(PCS)) – Conductivity and NMR techniques: Conductivity of water/oil microemulsions, percolating and non-percolating emulsions, bicontinuous emulsions – Viscosity of emulsions – NMR technique for measurement of self diffusion of all components in emulsions and explanation of the various structures		
UNIT V	**Stability of Emulsion**	**9**
Steric stabilization: Unfavourable mixing of the stabilizing chains – Entropic repulsion – Total energy – Distance curves for sterically stabilized emulsions – Variation of the energy curve with the ratio of adsorbed layer thickness to droplet radius – Thermodynamic stabilization: Reason for combining surfactant and cosurfactant to produce an ultra low interfacial tension – Formation of a model w/o emulsion using 4 steps – Relationship of droplet size to interfacial tension		

LECTURE	TUTORIAL	PRACTICAL	TOTAL
45	0	0	45

TEXT

1. Seid Mahdi Jafari, ―Encapsulation of nano-emulsions by spray drying‖, Lambert Academic Publishing, (2009).
2. Hans Lautenshlager ―Emulsions‖, Kosmetik International, (2002)

REFERENCES

1. Roque Hidalgo-Alvarez, ―Structure and Functional properties of Colloids‖, CRC Press, (2009).
2. Richard J. Fann, ―Chemistry and Technology of Surfactants‖, Wiley-Blackwell, (2006).

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<table>
<tr><td colspan="2">COURSE CODE</td><td>YNTE16</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td colspan="2">COURSE NAME</td><td>NANOTECHNOLOGY BUSINESS APPLICATIONS AND COMMERCIALIZATION</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td></td><td>L</td><td>T</td><td>P</td><td>H</td></tr>
<tr><td colspan="3"></td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>UNIT I</td><td colspan="5">Overview</td><td>9</td></tr>
<tr><td colspan="7">Introduction – types of nanobusinesses – ease of entry – intellectual property – ethics – risks/dangers –standardization, investors and commercialization centers – business applications – social aspects of nanotechnology</td></tr>
<tr><td>UNIT II</td><td colspan="5">Market Landscape</td><td>9</td></tr>
<tr><td colspan="7">Nanotechnology landscape and commercially attributable sectors - Tools to map, understand and segment the nanotechnology marketplace – Potential nanotechnology end-users and applications - Global market for nanotechnology products – Attracting venture capital –How to liaise effectively with partners - academy-industry relationship –University and employee's inventions</td></tr>
<tr><td>UNIT III</td><td colspan="5">Commerce and Regulation</td><td>9</td></tr>
<tr><td colspan="7">Frameworks for developing nanotechnology marketplace –Incentives for Commercial applications – Shaping the Nanotech Marketplace- Allocating Costs associated with Risks – Public perception of nanotechnology – Critical impact of Regulation of Nanotechnology – Environment, health and safety within the nanotechnology industry–
Developments that could influence the nanotechnology market – Impact for Future technologies</td></tr>
<tr><td>UNIT IV</td><td colspan="5">Business Structures</td><td>9</td></tr>
<tr><td colspan="7">Relationship b/w technology development and new business creation– the company concepts– new technology–new opportunity– sole proprietorships– general and limited partnerships– professional and closed corporations</td></tr>
<tr><td>UNIT V</td><td colspan="5">Materials Processing Economics</td><td>9</td></tr>
<tr><td colspan="7">Comparison and projection of yield– manufacturing output– labor and equipment expenses to calculate and estimate costs – relative performance enhancements for materials processing– alternate approaches– Identification of equipment– facilities and overheads – specific manufacturing methods– Tools to estimate the economics of process–Addressing the effect of</td></tr>
</table>

overall system costs – its benefits

LECTURE	TUTORIAL	PRACTICAL	TOTAL
45	**0**	**0**	**45**

TEXT

1. Sherron Sparks, Nanotechnology: Business Applications and Commercialization, CRC Press, Taylor & Francis group, London (2012).
2. Jeffrey H. Matsuura Nanotechnology Regulation and Policy Worldwide, Artech House; 1 Ed., (2006).

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1.Nanotechnology developments in India – A status report, The Energy and Resources Institute (TERI), India (2009).

2.Nanotechnology: a Realistic Market Assessment, Report Code: NAN031B, BCC Research, Market

Forecasting (2006).

3. Michael T. Burke, Nanotechnology: The Business, Perspectives in Nanotechnology, CRC Press, Colorado, USA (2008).

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COURSE CODE	**YNTE17**	**L**	**T**	**P**	**C**
COURSE NAME	**NANO – CMOS CIRCUITS AND PHYSICAL DESIGNS**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**Nano-Cmos Scaling Problems And Implications**	**9**
Design Methodology in the Nano-CMOS Era – Scaling – Overview of Sub-100-nm Scaling Challenges and Subwavelength Optical Lithography – Back-End-of-Line Challenges (Metallization) – Front-End-of-Line Challenges (Transistors) – Process Control and Reliability Lithographic Issues and Mask Data Explosion – New Breed of Circuit and Physical Design – Modeling Challenges – Need for Design Methodology Changes		
UNIT II	**Practicalities of Subwavelength Optical Lithography**	**9**
Simple Imaging Theory – Challenges for the 100-nm Node – e-Factor for the 100-nm Node – Corner Rounding Radius – Resolution Enhancement Techniques: Specialized Illumination Patterns – Optical Proximity Corrections –Subresolution Assist Features – Alternating Phase-Shift Masks – Physical Design Style Impact on RET and OPC Complexity – Specialized Illumination Conditions – Two-Dimensional Layouts – Alternating Phase-Shift Masks –Mask Costs		
UNIT III	**Process Scaling Impact on Design Mixed-Signal Circuit Design**	**9**
Design Considerations – Device Modeling – Passive Components – Design Methodology – Benchmark Circuits –Design Using Thin Oxide Devices – Design Using Thick Oxide Devices – Low-Voltage Techniques – Current Mirrors – Input Stages – Output Stages – Bandgap References – Design Procedures – Electrostatic Discharge Protection – Multiple-Supply Concerns – Noise Isolation – Guard Ring Structures – Isolated NMOS Devices – Epitaxial Material versus Bulk Silicon – Decoupling – Power Busing – Integration Problems – Corner Regions –Neighboring Circuitry		
UNIT IV	**Electrostatic Discharge Protection Design**	**9**
ESD Standards and Models – ESD Protection Design – ESD Protection Scheme – Turn-on Uniformity of ESD Protection Devices – ESD Implantation and Silicide Blocking – ESD Protection Guidelines – Low-C ESD Protection Design for High-Speed I/O – ESD Protection		

for High-Speed I/O or Analog Pins – Low-C ESD Protection Design – Input Capacitance Calculations – ESD Robustness – Turn-on Verification – ESD Protection Design for Mixed-Voltage I/O – Mixed-Voltage I/O Interfaces – ESD Concerns for Mixed-Voltage I/O Interfaces – ESD Protection Device for a Mixed-Voltage I/O Interface – ESD Protection Circuit Design for a Mixed-VoltageI/O Interface – ESD Robustness – Turn-on Verification – SCR Devices for ESD Protection – Turn-on Mechanism of SCR Devices – SCR-Based Devices for CMOS On-Chip ESD Protection

UNIT V	**Signal Integrity Problems in On-Chip Interconnects**	**9**

Interconnect Figures of Merit – Interconnect Parasitics Extraction – Circuit Representation of Interconnects – RC Extraction – Inductance Extraction – Signal Integrity Analysis – Interconnect Driver Models – RC Interconnect Analysis – RLC Interconnect Analysis – Noise-Aware Timing Analysis – Design Solutions for Signal Integrity –Physical Design Techniques – Circuit Techniques

LECTURE	TUTORIAL	PRACTICAL	TOTAL
45	**0**	**0**	**45**

TEXT

1. Ban P. Wong, Anurag Mittal, Yu CaoGreg Starr, "Nano-CMOS Circuit and physical design", John Wiley & Sons, Inc.Hoboken, New Jersey. (2000)

REFERENCES

1. Charles chiang, Jamil Kawa, "Design for manufacturability and yield for Nano - Scale CMOS", Springer, (2007).

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COURSE CODE	**YNTE18**	**L**	**T**	**P**	**C**
COURSE NAME	**PROPERTIES OF NANOPHASE MATERIALS**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**Structural Properties of Nano Materials**	**9**

Crystal structures of nano particles; lattice vibrations; size-dependent of properties; chemical & mechanical properties; catalytic properties of nano-materials. Mechanical properties: hardness, compressive & tensile strength; failure mechanisms of conventional grain-sized materials; mechanical properties of nano-structured multilayers; metal nano cluster composites; crystals of metal nano particles; nano particle lattices in colloidal suspensions; metallic glasses; shape memory alloys; thermodynamics & kinetics of phase transformations in synthesis of nano phase materials; structure: micro-structural stability; powder consolidation; properties of nano materials at low temperatures; thermal contact & isolation

UNIT II	**Electronic Properties of Nano-materials**	**9**

Energy bands & gaps in semiconductors; Fermi surfaces; localized particle, donors, acceptors, deep traps, excitons, mobility; size-dependent effects, conduction electrons & dimensionality, Fermi gas & density of states, potential wells, partial confinement; electronic properties of metal nano clusters, semi-conducting nanoparticles, single-electron unnelling, electronic properties of unnelli and similar nano structures. Thermo-mechanical unnellin of thin-film nano structures: a general framework for the thermo-mechanics of the multiplayer films, surface stress-scaling from micro to nano structures

UNIT III	**Optical Properties of Nano-materials**	**9**

Photonic crystals, optical properties of semiconductors, band edge energy, band gap dependence on nano crystalline size. Quantum dots; optical transitions; absorption; inter-band transitions; quantum confinements; fluorescence/luminescence; photoluminescence/fluorescence; optically excited emission; electroluminescence; Laser emission of quantum dot; photo fragmentation & Coulombic explosion; phonons in nano structures. Luminescent quantum dots for biological labelling

UNIT IV	**Magnetic Properties of Nano Materials**	**9**

Introduction of magnetic materials; basics of ferromagnetism; ferro-magnetic resonance & relaxation; magnetic properties of bulk nano structures; magnetic clusters; dynamics of nano magnets; nano-pore containment of magnetic particles; nano-carbon ferro magnets; giant & colossal magneto resistance; ferro fluids; electron transport in magnetic multi-layers; particulate nano magnets; geometrical nano magnets. Spintronics; spin polarized electron unnelling; interlayer exchange coupling; spin relaxation in magnetic metallic layers & multi-layers; non-equilibrium spin dynamics in laterally defined magnetic structures

UNIT V	**Biomaterials in Nanotechnology**	**9**

Metal nano particles; dendrimers; liposomes; property of nano materials in biosensor fabrication; near-field optics & nanofibers; bioreceptor (Antigen/Antibody, Enzymes, Nucleic acids/DNA, cellular structure/cells, biomimetic); nanocapsules; nanorods, DNA nano wires and other drug delivery vehicles; nano-crystalline structures of bone and calcium phosphate cements. Cobalt-based alloys; Titanium and its alloys; nano particles relating to Aluminum oxides; Hydroxyapatite; glass ceramics; ceramic implants; carbon implants. Nano shells – Tectodendrimers Nano particle drug systems; inorganic particle incorporated bionanocomposites.

LECTURE	TUTORIAL	PRACTICAL	TOTAL
45	0	0	45

TEXT

1. Askeland D.R.,& P. P. Fullay (2007), The Science and Engineering of Materials – 7thCengage Learning Publishers.
2. William D. Callister, Jr (2008), Callister‟s Materials Science and Engineering, (Adopted by R. Balasubramaniam) Wiley-Eastern

REFERENCES

1. "Amorphous & Nano crystalline Materials: Preparation, Properties & Applications," A. Inoue & K. Hashimoto (Eds.), Springer, 2001.

E REFERENCES

1. www.nptel.ac.in
2. www.mit.co.in

COURSE CODE	YNTE18	L	T	P	C
COURSE NAME	NANOMANIPULATION & ASSEMBLY	3	0	0	3
PREREQUISITES		L	T	P	H
		3	0	0	3

UNIT I	**Introduction**	9
Concept of manipulation in nanostructures & nanoassembly, experimental realization, limitation of present-day instrumentation, future out look		
UNIT II	**Nanomanipulation**	9
Buckling, Transport & Rolling at the nano scale. Instrumentation Systems: the nano manipulator & combined microscopy tools; nano manipulation for mechanical properties		
UNIT III	**Nano Particle Manipulation by Electrostatic Forces**	9
Theoretical aspects of AC electro kinetics; applications of dielectrophoresis on the nanoscale; limitations of nanoscale dielectrophoresis		
UNIT IV	**Biologically Mediated Assembly of Artificial Nanostructures**	9
Bio-inspired self-assembly; the forces & interactions of self-assembly; biological linkers; state-of-the-art in bio-inspired self-assembly; future directions		
UNIT V	**Nanostructural Architectures from Molecular Building Blocks**	9
Bonding & connectivity; molecular building block approaches		

	LECTURE	TUTORIAL	PRACTICAL	TOTAL
	45	0	0	45

TEXT

1. Electrochemical Nanotechnology by W.J. Lorenz and W.Pleith, IUPAC, Wiley Publications.
2. Handbook of Microscopy for nanotechnology by Nanyo, Zhong Lin Wang. Kluwer academic publish- 2005.

REFERENCES

1.“Handbook of Nanostructured Materials & Nanotechnology,” Hari Singh Nalwa (Ed.), Academic Press, 2000.
2.“Scanning Probe Microscopy & Spectroscopy: Theory, Techniques & Applications,” Dawn

A Bonnell, Wiley-VCH, 2001.

3.“Micro/Nanotechnology and its Applications,” B. Bhushan, Kluwer Publishers.

4. Robot Hands & Mechanics of Manipulation,” Matthew T. Mason & J. Kenneth Salisbury, MIT Press, 1985.

5. Micro & Nano manipulation tools by Yu Son, Xinyu Liu. Wiley Publications.

E REFERENCES

1. www.nptel.ac.in

2. www.mit.co.in

COURSE CODE	**YNT202**	**L**	**T**	**P**	**C**
COURSE NAME	**NANOMATERIALS CHARACTERIZATION TECHNIQUES**	**3**	**0**	**0**	**3**
PREREQUISITES		**L**	**T**	**P**	**H**
		3	**0**	**0**	**3**

UNIT I	**Introduction to spectroscopy**	**9**
Basic principles and applications of UV-Vis-NIR, FTIR, FT-Raman, Photoluminescence, NMR, ESR and Light Scattering methods.		
UNIT II	**X – ray techniques**	**9**
X-ray powder diffraction –Quantitative determination of phases; Structure analysis, single crystal diffraction techniques - Determination of accurate lattice parameters - structure analysis-profile analysis - particle size analysis using Scherer formula- Particle Size Analyzer- Ellipsometry-thickness measurements		
UNIT III	**Electron Spectroscopy**	**9**
X-Ray Photoelectron Spectroscopy, Auger Electron Spectroscopy, X-Ray Characterization of Nanomaterials – EDAX and WDA analysis – EPMA - Applications to nanomaterials characterization		
UNIT IV	**Mechanical, Magnetic and electrical properties measurement**	**9**
Nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions- models for interpretation of Nanoindentation loaddisplacement curves-Nanoindentation data analysis methods-Hardness testing of thin films and coatings- MD simulation of nanoindentation. Vibration Sample Magnetometer, Impedance Spectroscopy- PPMS, -Measurement of Magnetic and electrical properties of nanomaterials.		
UNIT V	**Electrometric Methods of Analysis**	**9**
Types of electrochemical cells; electrode potentials.Hall measurement; Quantum Hall Measurement; Dynamic and static Current-Voltage (I-V) characteristics; capacitance; voltage measurements; I-V analysis by AFM and STM (STS); electron beam induced current measurement (EBIC)		

	LECTURE	**TUTORIAL**	**PRACTICAL**	**TOTAL**
	45	**0**	**0**	**45**

TEXT
4. Skoog, Holler, Nieman " Principles of Instrumental Analysis" 5. Rainer Waser " Nanoscale Calibratin Standards"Wiley-VCH 6. Rainer Waser " Nanometrology"Wiley-VCH
REFERENCES
1. "Handbook of Nanostructured Materials and Nanotechnology," vols. 1-5, H. S. Nalwa (Ed.), Academic Press, 2000. 2. "Electron Microscopy and Analysis," P. J. Goodhews & F. J. Humphreys, Taylor and Francis. 3. "Modern Techniques of Surface Science," D. P. Woodruff & T. A. Delchar, Cambridge Solid State Science. 4. "Electronic Structure of Materials," A. P. Sutton, Oxford University Press, 1993. 5. "Semiconductor Materials & Device Characterization," D. K. Schroder, John Willy & Sons
E REFERENCES
3. www.nptel.ac.in **4.** www.mit.co.in