marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Suggested Learning Resources:

1. Guozhong Cao, "Nanostructures and Nanomaterials, synthesis, properties and applications", Imperial College Press, 2004
2. M.S. Ramachandra Rao, Shubra Singh, Nanoscience and Nanotechnology: fundamentals to Frontiers, Wiley 2013.
3. Introduction to Nanotechnology - Charles P. Poole Jr. and Franks. J. Qwens.

Semester- II

DESIGNANDFABRICATIONOFNANOMATERIALSANDDEVICES			
Course Code	**MNST201 / MINT201**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	4	Exam Hours	3

Course Learning objectives:

- The learning objectives of the course are to provide students with the knowledge of miniaturization concept and Quantum mechanical aspects.
- Understand the principles of Nanofabrication process; determine the suitability of nanostructures for fabrication of devices.
- The course provides a strong theoretical and analytical understanding of nanostructures and devices fabrication process for its applications.

Module-1

The Science of Miniaturization

Miniaturization of Electrical and Electronic Devices, Moore's law and technology road map, Quantum Mechanical Aspects, Simulation of the Properties of Molecular Clusters, Formation of the Energy Gap, Confinement Effects, Discreteness of Energy Levels, Tunnelling Currents.

Module-2

Nanofabrication by Photons

Principles of Optical Projection Lithography, Process of Optical Lithography. Photoresists Characteristics. Optical Lithography at Shorter Wavelengths-Deep UV, Extreme UV and X-ray Lithography. Optical Lithography at High Numerical aperture, Near-Field Optical Lithography.

Module-3

Nanofabrication by Ion Beam

Introduction, Liquid Metal Ion Sources, Focused Ion Beam Systems, Ion Scattering in Solid Materials , FIB Direct Nanofabrication , Ion Sputtering, Ion Beam Assisted Deposition, Applications, Focused Ion Beam Lithography, Ion Projection Lithography.

Module-4

Nanofabrication by Scanning Probes

Introduction, Principles of Scanning Probe Microscopes, Exposure of Resists- Exposure of Resist by STM, Exposure of Resist by NSOM, Additive Nanofabrication, Field Induced Deposition, Dip-Pen Nanolithography, Subtractive Nanofabrication-Electrochemical Etching, Field Induced Decomposition, Thermomechanical Indentation, Mechanical Scratching, High Throughput Scanning Probe Lithography.

Module-5

Fabrication of micro/nano devices

Microfluidic Devices - Microchannels, Microfilters, Micro- valves, Micropumps, Microneedles, Microreserviors, Micro-reaction chambers. Lithium Ion Battery and Super capacitors device fabrication, Operating and structure of Solar cells-CIGS solar cells, Dye-Sensitized solar cells, and Perovskite solar cell. MEMS and NEMS based devices`

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

TEXT BOOKS:

1. Guozhong Cao, Nanostructures & Nanomaterials Synthesis, Properties G; Z: Applications, World Scientific Publishing Private, Ltd., Singapore (2004).
2. W.R.Fahrner, Nanotechnology and Nanoelectronics – Materials, Devices, Measurement Techniques, SpringerVerlag Berlin, Germany (2006).
3. R. H. J. Hannink and A. J. Hill, Nanostructure control of materials, Woodhead Publishing Limited and CRC Press LLC, Cambridge, England (2006).
4. Zheng Cui, Nanofabrication, Principles, Capabilities and Limits, Springer Science + business media, New York (2008).

References:

1. Hari Singh Nalwa, Handbook of Nanostructured Materials and Nanotechnology (Vol. 3)- Electrical Properties, Academic Press, San Diego, USA (2000).
2. Huff, Howard, Into The Nano Era: Moore's Law Beyond Planar Silicon CMOS (Vol. 106), Springer Series in Materials Science, Springer-Verlag Berlin (2009).
3. Marc J. Madou, Fundamentals of Microfabrication: The Science of Miniaturization, 2nd Edition, CRC Press, California, USA (2002).
4. Kostya (Ken) Ostrikov and Shuyan Xu, Plasma-Aided Nanofabrication: From Plasma Sources to Nanoassembly, WILEY-VCH Verlag GmbH & Co. KGaA (Weinheim) (2007).

Web links and Video Lectures (e-Resources):

- Nanomaterials Science and Nanomanufacturing: Dr. Kantesh Balani & Dr. Anandh Subramaniam, IIT Kanpur: https://www.youtube.com/watch?v=rDJOzKRGJm8
- Lithography: Prof. A.K. Ganguli, IIT Delhi: https://www.youtube.com/watch?v=ugif3s7a6h8
- Focused Ion beam machining: https://www.youtube.com/watch?v=pWYHVsu7Fhk
- Overview of Scanning Probe Lithography: https://www.youtube.com/watch?v=MshGAYYNZ8o

Skill Development Activities Suggested

- Quizzes
- Assignments
- Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Understand and appreciate the importance of nanostructure and its impact device fabrication	Understand
CO2	Differentiate between nanofabrication process and understand the advantages and limitations of process for device fabrication	Analyze
CO3	Explain the miniaturization of devices to Nano devices, process challenges and analyse theory for emerging Nano scale devices	Understand
CO4	Evaluate the advances in Nano scale technology and device fabrication their application in electronics, sensors, biomedical and energy generation and storage.	Evaluate

Program Outcome of this course

Sl. No.	Description	POs
1	Engineering knowledge	1
2	Problem analysis	2
3	Design/development of solutions	3
4	Conduct investigations of complex problems	4
5	Modern tool usage	5
6	The engineer and society	6
7	Environment and sustainability	7
8	Ethics	8
9	Life-long learning	12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x											
CO2	x	x	x	x	x							
CO3	x											
CO4	x	x	x	x	x	x	x	x				x

Semester- II

NANOMATERIALS FOR ENERGY GENERATION AND STORAGE			
CourseCode	**MNST202 / MINT202**	CIEMarks	50
TeachingHours/Week(L:P:SDA)	2:0:2	SEE Marks	50
TotalHoursofPedagogy	40	TotalMarks	100
Credits	3	ExamHours	3

Course Learning Objectives:

1. Learn about basic principles of different renewable energy technology.
2. Apply nanomaterial in improving renewable energy storage and generation application.
3. Understand the nanosize and morphology influence on improving energy generation and storage efficiency.

Module-1

Renewable energy Technology: Energy challenges, nanomaterials and nanostructures in energy harvesting, developments and implementation of nanotechnology based renewable energy technologies, solar cell structures: quantum well and quantum dot solar cells, photo-thermal cells for solar energy harvesting, thin film solar cells, CIGS solar cells, Dye sensitized solar cells. Organic PV cells, Concentrated solar power (CSP): Reflective materials, absorptive coatings, thermal storage.

Module-2

Energy storage: Introduction, Battery types, Li-ion Battery, Battery components materials, cathodes, anodes, effect of nanosize on energy storage and electrode materials performance. Next generation batteries, Li-Air, Li-S, Na ion battery, Mg ion battery. LIB for automobiles application, EV's, HEV, PHEV and power grid.

Module-3

Super capacitors: Introduction, Electrochemical energy storage, Electrochemical capacitors, Electrochemical double layer capacitor, electrode materials supercapacitors, Hybrid Nanostructures for supercapacitors- metal oxides, conducting polymers, Electrolytes for super capacitors, types of electrolytes.

Module-4

Hydrogen Generation and storage technology: Hydrogen production methods, Concept of Grey, Blue and Green Hydrogen production, Electrochemical and photocatalytic H_2 Generation using Nanomaterials, purification, hydrogen storage methods and materials: metal hydrides and metal organic framework materials, volumetric and gravimetric storage capacities, hydriding and dehydriding kinetics, high enthalphy formations and thermal management during hydriding reaction, multiple catalytic- degradation of sorption properties, automotive applications. Catalyst of hydrogen production, steam reforming & Water splitting. Nanoporous membranes for hydrogen separation.

Module-5

Fuel cell technology: Fuel cell principles, types of fuel cells (Alkaline Electrolytie, phosphoric acid, Molten carbonate, solid oxide and direct methanol and proton exchange fuel cells), Principle and operation of proton exchange membrane (PEM) fuel cell, materials and fabrication methods for fuel cell technology, micro fuel cell power sources-biofuels.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

SuggestedLearningResources:

Text Book

1. D. Linden, Handbook of Batteries and Fuel Cells, Mcgraw-Hill, Noew York,1984
2. W. A. van Schalkwijk and B. Scrosati, Advances in Lithium- Ion Batteries, Kluwer Academic Publishers, Newyork, 2002
3. Linden , D. and Reddy , T.B. (2002) Handbook of Batteries , 3rd edn , McGraw - Hill , New York.

Reference

4. Crompton, T.R. (2000) Battery Reference Book , 3rd edn , Newnes , Oxford .
5. K. E. Aifantis and S. A. Hackney and R. Vasant Kumar, High Energy Density Lithium Batteries, Wiley-VCH Verlag, 2009.
6. University of Cambridge (2005) DoITPoMS Teaching and Learning Packages,http://www.doitpoms.ac.uk/tlplib/batteries/index.php (accessed 5 February 2010).
7. K.K.Jain, Nano Biotechnology, Horizions Biosciences, 2006

WeblinksandVideoLectures(e-Resources):

1. **Nano Materials for Energy Conversion and Storage : https://youtu.be/YVNplIT-Diw**
2. **Hydrogen Production: https://youtu.be/JGe8R0N20ps**
3. **Hydrogen Energy: Production, Storage, Transportation and Safety: https://youtu.be/anDF-nUHZW4?list=PLOzRYVm0a65dtZiqOUeyWCiCWL4vWaDwj**
4. **Super Capacitors: https://youtu.be/DJ0Agkp8WlQ**

SkillDevelopmentActivitiesSuggested

- Assignments
- Quizes
- Seminars

Courseoutcome(CourseSkill Set)
At theend ofthe coursethestudent willbeable to:

Sl. No.	Description	BloomsLevel
CO1	Demonstratetheknowledgeon concepts of advances in Renewable energy technologies	Apply
CO2	Evaluatethe suitablenanostructurefor improving energy storage and generation efficiency of the systems. .	Apply

ProgramOutcomeof thiscourse

Sl. No.	Description	POs
1	Engineeringknowledge	1
2	Problemanalysis	2
3	Design/developmentofsolutions	3
4	Conductinvestigationsofcomplex problems	4
5	Moderntoolusage	5
6	Individual and team work	9
7	Communication	10
8	Life long learning	12

MappingofCOSandPOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x	x	x	x	x				x	x		x
CO2	x	x	x	x	x				x	x		x

Semester- II

CARBON BASED NANOSTRUCTURES			
Course Code	**MNST203 / MINT203**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	

Course Learning objectives:

1. Introduce type of carbon based nanostructures tubes
2. Learn about the synthesis methods and growth mechanisms.
3. Understand different properties and applications of carbon nanotubes in various fields.
4. Importance of functionalization of carbon nanostructures

Module-1

Carbon Nanotubes (CNT): History, types of CNTs, synthesis methods, CVD method, Laser ablation and electric arc processes, growth mechanisms, purification and characterization methods, mechanical reinforcements, solid disordered carbon nanostructures.

Module-2

Graphene: Background, structure, exfoliation or synthesis methods- physical methods- micromechanical (scotch tape method), CVD, electric arc process. Chemical approaches-Hammers method, oxidation and reduction of graphite, solvothermal, supercritical fluid, solvent sonication method, chemically modified graphene, electrochemical synthesis and other methods

Module-3

Fullerenes and derivatives: Fullerenes and types, diamond like carbon, nanodiamond, clusters, metal carbide derived carbon nanostructures, synthesis and applications.
Nanostructures: Graphite, Whiskers, Cones, and Polyhedral crystals, structure, properties and applications. **Properties of Carbon nanostructure:** Electronic, Vibrational, Mechanical Properties of CNTs, optical properties & Raman spectroscopy of CNTs.

Module-4

Functionalization of carbon nanostructures: (CNT, Graphene and fullerenes)- reactivity, covalent functionalization-oxidative purification, defect functionalization, transformation and modification of carboxylic functionalization like amidation, thiolation, halogenations, hydrogenation, addition of radicals, sidewall functionalization through electorphilic addition, nano covalent exohedralfunctionalization, endohedro functionalization.

Module-5

Advanced 2D nanostructures: Introduction to 2D nanostructures,Structure and properties of metal nitrides, carbides, selenides, sulphides, metal dichalcogenides, MXenes.Synthesis methods and surface chemistry, functionalization of MXenes. Applications of 2D nanostructures

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

.

Suggested Learning Resources:

Books

TEXT BOOKS:

1. Carbon Nanotubes: properties and applications-Mchael J. O'Connell, Taylor & Francis, 2006
2. Nanotubes and Nanowires-CNR Rao and A Govindaraj RSC publishing
3. Handbook of Carbon, YuryGagotsi, Taylor & Francis, 2006
4. Mxenes and their Composites Synthesis, Properties and Potential Applications. Edited by Kishor Kumar Sadasivuni. Elsevier, 2022. https://doi.org/10.1016/C2019-0-05458-1

Reference

1. Physical properties of carbon nanotube- R. Satio
2. Applied physics of Carbon nanotubes: fundamentals of theory, optics and transport devices-S.Subramoney and S.V.Rotkins
3. Carbon nanotechnology-Liming Dai

Web links and Video Lectures (e-Resources):

- Fullerenes and Carbon nanotubes: https://www.youtube.com/watch?v=9EKqNBvz4cA
- Carbon Materials and Manufacturing https://www.youtube.com/watch?v=AzyYyjPEqOk&t=1s
- Carbon Nanostructures https://www.youtube.com/watch?app=desktop&v=kCTED1wlQBU

Skill Development Activities Suggested

- Quizzes
- Assignments
- Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Identify the type of carbon nanotubes and different synthesis methods and growth mechanisms	Understand
CO2	Elucidate different properties and applications of carbon nanotubes in various fields and Understand the importance offunctionalization of carbon nanostructures their application of carbon nanostructure for different day-to-day applications	Apply

Program Outcome of this course

Sl. No.	Description	POs
1	Engineering knowledge	1
2	Problem analysis	2
3	Design/development of solutions	3
4	Conduct investigations of complex problems	4

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x											
CO2	x	x	x	x	x							

Semester- II

Semiconductor Technology			
Course Code	**MNST204 / MINT204**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	03

Course Learning objectives:

- The course provides a strong theoretical and analytical understanding of basic of semiconductor devices (ICs, LED, CMOS etc) fabrication process and its applications.

Module-1

Basic fundamentals in semiconductor technology

Explain the science behind semiconductor technology (overview): The atomic bond, the ionic bond, the metallic bonding, intermolecular bonding: chemical bonds, electrostatic, hydrogen, Van der Waals, and shear interaction; define self-assembly, diffusion, sintering, absorption, and adsorption. Define types of materials: conductors, insulators, n and p type of semiconductors. Band model: valence bonds, energy bands, intrinsic carrier concentration

Module-2

Crystal growth and epitaxy: Overview

Basic crystal structures. Wafer fabrication: properties of silicon, production of raw silicon, single crystal silicon: production by Czochralski (CZ) method, silicon float-zone process, GaAs crystal-growth techniques, epitaxial-growth techniques. structures and defects in epitaxial layers

Module-3

Film formation:

Deposition: Plasma state and plasma generation, chemical and physical vapour deposition, atom layer deposition. Doping techniques: furnace diffusion methods and ion implantation. Oxidation: thermal oxidation, properties of oxide layers. Film thickness measurements: Metrology, interferometry, and ellipsometry.Metallization: Metal semiconductor junction, aluminium diffusion in silicon, aluminium electromigration, low k copper technology.

Module-4

Lithography and Etching

CAD (computer aided design) process and GDS file generation for lithography exposure, principles of Optical Lithography: photoresists characteristics, photoresist coating and exposure.

Exposition methods: contact exposure, proximity exposure. electron beam lithography, and X-ray lithography. Development and inspection: development, inspection, resist removal from wafer and photomasks. Wet and dry etching: anisotropic and isotropic etching, process gasses used in dry etch, ion beam etching and plasma etching, reactive ion etching.

Module-5

Semiconductor device and applications: Chip bonding and packaging (basic application only).

Define types of devices: The p-n junction, field-effect transistors, photodetectors and solar Cells, and light emitting diodes and lasers (PMOS, NMOS, CMOS, nano-transistors, LED, and Schottky device)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

.

Suggested Learning Resources:

Books

TEXTBOOKS:

1. Semiconductor devices: Physics and Technology,S. M. Sze and M. K. Lee, 3rd edition, John & Wiley, , New York, NY, ISBN 978-0470-53794-7, 2012
2. Zheng Cui, Nanofabrication, Principles, Capabilities and Limits, Springer Science + business media, New York (2008).

References:

1. Marc J. Madou, Fundamentals of Microfabrication: The Science of Miniaturization, 2nd Edition, CRC Press, California, USA (2002).
2. Kostya (Ken) Ostrikov and Shuyan Xu, Plasma-Aided Nanofabrication: From Plasma Sources to Nanoassembly, WILEY-VCH Verlag GmbH & Co. KGaA (Weinheim) (2007).

Web links and Video Lectures (e-Resources):

- . Nanomaterials Science and Nanomanufacturing: Dr. Kantesh Balani & Dr. Anandh Subramaniam, IIT Kanpur: https://www.youtube.com/watch?v=rDJOzKRGJm8
- Lithography: Prof. A.K. Ganguli, IIT Delhi: https://www.youtube.com/watch?v=ugif3s7a6h8
- Focused Ion beam machining: https://www.youtube.com/watch?v=pWYHVsu7Fhk
- Overview of Scanning Probe Lithography: https://www.youtube.com/watch?v=MshGAYYNZ8o
- https://www.halbleiter.org/pdf/en/Semiconductor%20Technology/Semiconductor%20Technology%20from%20A%20to%20Z.pdf

Skill Development Activities Suggested

- Quizzes
- Assignments
- Seminars

Course outcome (Course Skill Set)

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

S/N	Description	Blooms Level
CO1	Understand and appreciate the importance of semiconductor technology and its impact device fabrication	Understand
CO2	Analyze fabrication process and understand the advantages and limitations of process for device fabrication	Analyze
CO3	Explain the miniaturization of devices, process challenges, and analyse theory for emerging semiconductor device	Understand
CO4	Evaluate the advances in semiconductor technology and device fabrication their application in electronics, sensors, biomedical and energy generation and storage.	Evaluate

Program Outcome of this course

Sl. No.	Description	POs
1	Engineering knowledge	1
2	Problem analysis	2
3	Design/development of solutions	3
4	Conduct investigations of complex problems	4
5	Modern tool usage	5
6	The engineer and society	6
7	Environment and sustainability	7
8	Ethics	8
9	Life-long learning	12

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x											
CO2	x	x	x	x	x							
CO3	x											
CO4	x	x	x	x	x	x	x	x				x

Semester- II

NANO ELECTRONICS			
Course Code	**MNST215A/MINT215A**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	03

Course Learning objectives:

- To understand the importance of nanoelectronics, technology roadmap in nanoelectronics and limitations of existing CMOS technologies for design of electronic circuits.
- The course provides an insight on the advances in nanoelectronics devices such as High-K devices, FINFETs, CNTFETs, Molecular Electronics and Spintronics.
- The course provides a strong theoretical and analytical understanding of nanoelectronic devices and its applications in design of electronic circuits.

Module-1

Introduction to Nanoelectronics

Technology roadmap of nano-electronics, Scaling of devices and technology jump, Challenge of the CMOS technologies, More-Moore and More-than-Moore. Review of semiconductor devices, Quantum statistical mechanics, Energy bands in silicon, **Metal Oxide Semiconductor Field Effect Transistors (MOSFET),** MOSFET Operation, Threshold Voltage and Subthreshold Slope, Current/voltage characteristics, Finite Element Modeling of MOS, CMOS technology, Challenges of the CMOS technologies, High-k dielectrics and Gate stack, Future interconnect.

Module-2

Nanoscale MOSFETs

MOSFET as digital switch, Propagation delay, Dynamic and static power dissipation Moore's law, Transistor scaling, Constant field scaling theory, Constant Voltage Scaling, Generalized scaling, Short channel effects, Reverse short channel effect, Narrow width effect, Subthreshold conduction leakage, Subthreshold slope, Drain Induced Barrier Lowering, Gate Induced Drain Leakage, Design of NanoMOSFET, Halo implants, Retrograde channel profile, Shallow source/drain extensions, Twin well CMOS process flow, Gate Tunneling : Fowler Nordheim and Direct Tunneling, High k gate dielectrics, Metal gate transistor, Transport in Nanoscale MOSFET, Ballistic transport, Channel quantization.

Module-3

Designing with FINFETs

Evolution of FinFET, Principle of FinFET, Finfet Technology, Fin FET Schematic, Compact Drain-Current equation, Small Signal Model of Si- Based FinFET, Fin FET Fabrication Flow, Power dissipation in FinFETs, Leakage power reduction techniques, Power gating, Dual sleep, Dual stack, Sleepy stack, Basic gate design using FinFET's, combinational logic, sequential logic, Adders, Multiplier, SRAM cell design

Module-4

Designing with CNTFETs

Introduction to CNTs, CNT structure, metallic and semiconductor CNTs, energy bands in CNTs, types of CNTs: Single walled and multiwalled, physical, electrical and thermal properties of CNTs, fabrication of CNTs. CNTFETs, structure and model, small signal model, predictive technology models, N-Channel and P-Channel CNTFETs, model files of CNTFETs, basic gates using CNTFET, VI characteristics of CNTFET based inverter, designing of sub systems using CNTFETs, combinational and sequential circuits using CNTFETs, adders, multipliers and SRAM cell using

CNTFETs.

Module-5

Advances in Nanoelectronics

MOLECULAR NANOELECTRONICS: Electronic and optoelectronic properties of molecular materials, TFTs- OLEDs- OTFTs – logic switches, SPINTRONICS: Spin tunneling devices - Magnetic tunnel junctions- Tunneling spin polarization, -spin diodes - Magnetic tunnel transistor - Memory devices and sensors - ferroelectric random access memory- MRAMS

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

.

Suggested Learning Resources:

Books

1. Understand the technology migration from MOS to nano devices, process challenges and analyse the mathematical models for emerging Nanoscale devices
2. Design logic circuits, sub systems and complex digital circuits using FINFETs and
3. Evaluate the advances in Nanoscale technology development and understand the importance of emerging devices and technologies of molecular electronics and spintronics

Web links and Video Lectures (e-Resources):

- . Semiconductor Optoelectronics, Prof. M. R. Shenoy, IIT Delhi: https://www.youtube.com/watch?v=Dt5kbf8JbJ0
- Nanoelectronics: Devices and Materials, FD SOI MOSFET, Prof. Navakanta Bhat, IIT Bangalore: http://www.infocobuild.com/education/audio-video-courses/electronics/NanoelectronicsDevicesMaterials-IIT-Bangalore/lecture-21.html
- Optoelectronic Materials and Devices, Prof. Monica Katiyar & Prof. Deepak Gupta, IIT Kanpur: https://www.youtube.com/watch?v=MC1zGEmrELA
- Single Electron Transistors, Coulomb Blockade: Dr. Madhu T., IITM: https://www.youtube.com/watch?v=OYJuwrsJu8s

Skill Development Activities Suggested

- Assignments
- Quizes
- Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Understand and appreciate the importance of nanoelectronics and its impact in next generation electronics and electronic products	Understand
CO2	Differentiate between MOS and emerging nanodevices technology, understand the advantages and limitations of MOS based circuits	Analyze
CO3	Understand the technology migration from MOS to nano devices, process challenges and analyse the mathematical models for emerging Nanoscale devices	Create
CO4	Design logic circuits, sub systems and complex digital circuits using FINFETs and CNTFETs	Create
CO5	Evaluate the advances in Nanoscale technology development and understand the importance of emerging devices and technologies of molecular electronics and spintronics	Evaluate

Program Outcome of this course

Sl. No.	Description	POs
1	Engineering knowledge	1
2	Problem analysis	2
3	Design/development of solutions	3
4	Conduct investigations of complex problems	4
5	Modern tool usage	5
6	The engineer and society	6

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	x	x								
CO2	x	x	x	x	x					
CO3	x	x	x	x	x	x				
CO4	x	x	x	x	x	x				
CO5	x	x	x	x	x	x				

Semester- II

NANO MATERIALS AND TECHNOLOGY FOR THE ENVIRONMENT			
Course Code	**MNST215B**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To learn applications of different nanomaterials for Environmental remedies, removal of pollutant from exhaust gases.
- Understand the effect of nanoparticle on health and environment and their toxicology.
- To introduce controlled environment, types of cleanrooms and their importance.

Module-1

Environmental Application of Nanomaterials

Metal oxide nanoparticles organic contamination remediation, Nano active materials, Advanced photocatalyst, removal organic contamination from waste water using Nanomaterials based photocatalyst. Nanostructure electrode for Electrochemical oxidation.

Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Module-2

Nanostructured catalytic materials

Nanostructured metals like Pt, Pd and Fe, nanostructured ceramics like silica, silicate and alumina, pillared clays, colloids and porous materials. Nanomaterials as catalyst for exhaust gas treatment such as CO_2, H_2S, Pb, NO.

Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Module-3

Nanomaterials as Adsorbents

Meosoporous materials-synthesis and characterization, properties and application with suitable examples, unipore size, bimodal pore size. Nanoporous materials- synthesis and application. Adsorption at the Oxide Nanoparticles/Solution Interface, Nanomaterial-Based Removal of nanoparticles-Principle of particle removal - Removal of nanoparticles suspended in gas - Removal of nanoparticles in liquid. Adsorption of hazardous chemicals by metal oxide nanoparticles, Adsorption of chemical warfare agents by metal oxide nanoparticles. Nanomaterials as adsorbents for Heavy metal removal from water and Wastewater Treatment, Nanomaterials for Groundwater Remediation- Reactivity, Fate, and Lifetime Delivery and Transport Issues.

Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Module-4

Nanotoxicology

Health effects on nanoparticles - Inhalation of nanomaterials–overview, Nanoparticle exposure and systematic cardiovascular effects. Respiratory particulate matter exposure and cardiovascular toxicity, Toxicity of different nanomaterials, Toxicological assessment of nanoparticles: Toxicity of polymeric nanoparticles. Eco-toxicological Impacts of Nanomaterials. Nanoparticles in atmospheric environment, Ground water environments, Waste water and in exhaust gases - Industrial processes and nanoparticles. Safety of nanoparticles- Problems caused by nanoparticles - Safety assessment for the nanoparticles.

Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Module-5

Cleanroom basics, hazards, and safety

Basics of cleanroom classification and ISO standards, sources of particulate contamination, clean air devices, special construction materials for cleanroom, and surface finishes. The HEPA filters and filtration process in the clean rooms. Parameters control in cleanrooms: temperature, RH, air volume and velocity, pressurization,

and differential pressure. Potential hazards in cleanrooms: Fire, explosions, toxicity, and physical hazards. Cleanroom operational and behavioural requirement. Material handling issues: DI water, solvents, cleaners, ion implantation sources, diffusion sources, photoresists, developers, metals, dielectrics, toxic gases, flammable, corrosive, and packaging materials. Types of cleanroom waste: handling and disposal of chemical, biological, infectious, radioactive, and mixed waste.

Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

TEXT BOOKS:

1. Glen E. Fryxell, Guozhong Cao, Environmental Applications of Nanomaterials: Synthesis, Sorbents and Sensors
2. Mark R. Wiesner, Jean-Yves Bottero, Environmental Nanotechnology: Applications and Impacts of Nanomaterials
3. J. B Park, "Biomaterials Science and Engineering", Plenum Press, New York, 1984.
4. P.P. Simeonova, N. Opopol and M.I. Luster, "Nanotechnology - Toxicological Issues and Environmental Safety", Springer 2006.

References:

1. J.J. Davis, Dekker, "Encyclopedia of Nanoscience and nanotechnology".
2. Dracy J. Gentleman, Nano and Environment: Boon or Bane? Environmental Science and technology, 43 (5), P1239, 2009
3. Vinod Labhasetwar and Diandra L. Leslie, "Biomedical Applications of nanotechnology", A John Willy & Son Inc, N.J, USA, 2007.
4. Cleanroom Technology: Fundamentals of Design, Testing, and Operation by William White, Print ISBN 0-471-86842-6, John Wiley & Sons Ltd, 2001
5. Hazardous Waste Management by Michael D. LaGrega, Reissue edition, ISBN-13: 978-1577666936, Waveland Press Inc., 2010

Web links and Video Lectures (e-Resources):

- Magnetic Nanocomposite for Wastewater Treatmen: https://www.youtube.com/watch?v=M3lXWqlw1DA
- Introduction to catalysts and catalysis: Prof. A.K. Suresh,Prof. Sanjay M. Mahajani & Prof. Ganesh A. Viswanathan, IIT Bombay: https://www.youtube.com/watch?v=jeUW6h2oVEY
- Photocatalysis: Prof. A.K. Ganguli,IIT Delhi: https://www.youtube.com/watch?v=yFdDdcJfncY
- Adsorption and Ion Exchange: IIT Kharagpur: https://www.youtube.com/watch?v=_LSKHSQmwwE
- Cleanroom Training Video: https://www.youtube.com/watch?v=Um0VA6iycY4
- Cleanroom classifications: https://www.youtube.com/watch?v=IENbOfC4df8

Skill Development Activities Suggested

- Assignments
- Quizes
- Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Apply nanomaterials in different environmental applications.	Apply
CO2	Demonstrate knowledge about the nanoparticles effect on health and safety issues.	Apply
CO3	Understand Nanoparticles toxicity and their effect on health.	Understand
CO4	Understand Importance of clean rooms and their usage.	Understand

Program Outcome of this course

Sl. No.	Description	POs
1	Engineering knowledge	1
2	Problem analysis	2
3	Design/development of solutions	3
4	Conduct investigations of complex problems	4
5	Modern tool usage	5
6	The engineer and society	6
7	Environment and sustainability	7
8	Ethics	8
9	Life-long learning	12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x	x			x			x				x
CO2	x	x	x	x	x	x	x	x				x
CO3	x	x			x			x				x
CO4	x	x			x			x				x

Semester- II

SELF ASSEMBLY OF NANOSTRUCTURES			
Course Code	**MNST215C**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To Extend their knowledge of design of innovative nanostructured materials based on basic chemistry, physics, biology and self assembly concepts applied to nanoelectronics, nanophotovoltaic and energy materials
- Self-assembly of nanomaterials and their nanohybrids for technological applications

Module-1

Self organization of nanostructured materials, Growth Mechanism, Self assembly of Nanostructures: Chemical, physical and biological self assembly, Assembling and patterning of particles, Self organization of different Nano-morphologies (Quntum Dots, Nanorods, Nanowires and Nanotubes).

Module-2

Self Assembled Monolayers (SAM), Guided Self Assembly - Nanolithography - Surface Topography - Surface Wetting - Electrostatic force; Nanomanipulators - Grippers – design - gripper arm geometry.

Module-3

Bottom-up manufacturing: bottom-up approach, Self-assembly of single electron transistors, Photovoltaic related devices, Langmuir Bladgett films (LB): principle of formation of monolayer formation – from molecules to nanoparticles, compression of monolayer-fabrication of LB films- applications.

Module-4

Self-Assembly by micro contact printing- creating the stamp, substrate- creating self assembled monolayers - applications, Macroscopic expressions of Natural Nanomaterials- Hierarchical Ordering in Natural Nanoscale Materials

Module-5

Bio-Inspired Approach for Complex Superstructures and Biological World, Self Assembly in biological systems: Superhydrophobicity, Self cleaning property, Multi scale ordering and function in Biological Nanoscale Materials: Proteins, Lipids, DNA and RNA and Shell as a Composite Materials.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

1. Self Organized Nanoscale Materials: Nanostructure Science and Technology by Motonari Adachi and David J. Lockwood, 2006 Springer Science, Business Media, Inc. NY, USA
2. Self-Assembled Nanostructures: Jin Z. Zhang, Zhong-lin Wang, Jun Liu, Shaowei Chen, and Gang-yu Liu, 2003 Kluwer Academic/Plenum Publishers, NY, USA
3. Nanoparticles: Theory to Applications by Günter Schmid, 2010 WILEY-VCH Verlag GmbH & Co. KGaA, Boschstr. 12, 69469 Weinheim.
4. Hand Book of Nanotechnology, by Bharat Bhushan, 2007, Springer Science+Business Media, Inc, NY, USA.
5. Prospects in Nanotechnology: Toward Molecular Manufacturing, Markus Krummenacker and James Lewis (Editors), Wiley 1995.

Web links and Video Lectures (e-Resources):

- Nano structured materials-synthesis, properties, self assembly and applications, Prof. A. K. Ganguli, IIT Delhi: https://www.youtube.com/watch?v=iZi-xIDBGH0
- Self Assembled Monolayers (SAM): https://www.youtube.com/watch?v=kPnweOCTnZI
- Langmuir Bladgett films (LB): https://www.youtube.com/watch?v=8zslCUnXrHg
- Microcotact printing: https://www.youtube.com/watch?v=uEKqOAIDei4
- Superhydrophobicity: https://www.youtube.com/watch?v=27bq3o3y8Os

Skill Development Activities Suggested

- Assignments
- Quizes
- Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Demonstrate self-assembled nanostructures	Apply
CO2	Understand bottom-up manufacturing	Understand
CO3	Create bioinspired things for society	Apply

Program Outcome of this course

Sl. No.	Description	POs
1	Engineering knowledge	1
2	Problem analysis	2
3	Design/development of solutions	3
4	Conduct investigations of complex problems	4
5	Modern tool usage	5
6	The engineer and society	6
7	Environment and sustainability	7

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x	x	x	x	x							
CO2	x	x										
CO3	x	x	x	x	x	x	x					

Semester- II

INTRODUCTION TO NANO BIOTECHNOLOGY			
Course Code	**MNST215D**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To provide fundamental aspects of biotechnology.
- To understand the interaction of nanostructures and biomolecules
- To learn to use various nanomaterials in biological application.

Module-1

Fundamentals of Biotechnology

Basic terms in biotechnology, recombinant DNA technology, genetic engineering, gene cloning. Development of nanobiotechnology, timelines and progress. Basics of cell orgenells. Biomacromolecules-carbohydrates, lipids, proteins and nucleic acids, PHA, cyanophcin inclusion, magnetosome, alginates, bacteriophages, S-layer protein, bacteriorhodpsin. Biological building blocks; Sizes of building blocks and comparison with nanostructures.

Module-2

Nanostructures:

DNA and protein based nanostructures, DNA origami, DNA nanotubes, polypeptide nanowire and protein nanoparticles, SAM, biological nanomotor. Nanoconjugates: DNA-gold nanoconjugates. DNA based nanoelectronics: immobilization of DNA on substrates, probing the electronic properties of single DNA molecules. Manipulation of DNA on metal surfaces.

Module-3

Interaction between biomolecules and nanoparticle surface

Different types of inorganic materials used for the synthesis of hybrid nano-bio assemblies, Application of nano in biology, nanoprobes for Analytical Applications - A new methodology in medical diagnostics and Biotechnology, Current status of Nanobiotechnology, Future perspectives of Nanobiology.

Module-4

Applications of nanomaterials

Drug delivery and gene delivery, Nanobiochips, biosensors. Nanomaterials in bone substitutes and dentistry. Polymeric nanofibres-tissue engineering, smart capsules, microemulsions, nano based cancer therapy, nanorobotics. Lotus leaf as a model self-cleansing system. Diatoms as example for silicon biomineralization. Biomechanical strength properties of Spider silk.

Module-5

Photoinduced Electron Transport in DNA

Electronic Devices Based on DNA Architecture, DNA Nanowires, Charge Transport, DNA-Based Nanoelectronics, Electrical Manipulation of DNA on Metal Surfaces, Nanostructured Bio-compartments, DNA-Gold nanoconjugates.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

TEXT BOOKS:

1. Nanobiotechnology: Bioinspired devices and materials of the future by OdedShoseyov, Ilan Levy. Humana Press 2010.
2. Bionanotechnology - Global Prospects by David E. Reisner, Taylor & Francis Group, LLC, 2009.
3. Nanotechnology in Drug Delivery by Melgardt M.deVilliers, PornanongAramwit, Glen S. Kwon, Springer-American Association of Pharmaceutical Scientists Press 2009.

References:

1. T. Pradeep , "NANO The Essential , understanding Nanoscience and Nanotechnology". Tata McGraw-Hill Publishing Company Limited, 2007.

2. Nancy A. Monteiro-Riviere, C. Lang Tran Nanotoxicology: Characterization, Dosing and Health Effects Published:July 25, 2007 by CRC Press

Web links and Video Lectures (e-Resources):

- . Fundamental of Biology & Biotechnology: Dr. Rintu Banerjee, IIT Kharagpur: https://www.youtube.com/watch?v=m_Xrh5uJFJo
- DNA Nanotechnology: https://www.youtube.com/watch?v=ZQf7ewZGZXg
- Nanomaterials for Cancer Therapy: Prof. P. Gopinath, IIT Roorkee: https://terna.digimat.in/nptel/courses/video/102107058/L12.html
- Nanomedicine & Drug delivery: IIT Bombay: https://www.youtube.com/watch?v=oYGfoj18izA

Skill Development Activities Suggested

- Assignments
- Quizes
- Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Demonstrate knowledge of biotechnology to understand Nanobiotechnology.	Apply
CO2	Analyze the interaction of various biomolecules and nanostructures.	Analyze
CO3	Design and develop nanostructures and biomolecules for various biological applications.	Create

Program Outcome of this course

Sl. No.	Description	POs
1	Engineering knowledge	1
2	Problem analysis	2
3	Design/development of solutions	3
4	Conduct investigations of complex problems	4
5	Modern tool usage	5
6	The engineer and society	6
9	Life-long learning	12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x	x	x	x	x							
CO2	x	x	x	x	x							
CO3	x	x	x	x	x	x						x

Semester- II

MEMs/NEMs AND MICROSYSTEMS			
Course Code	**MNST216A/MINT216A**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- Learn about basics and typical applications of microsystems
- Illustrate scaling laws & microsensors and microactuators
- Illustrate the various principles of operations of mems transducers
- Learn basic electrostatics and its applications in MEMS sensors and actuators
- Learn about ways to fabricate& a packaging needs MEMS device

Module-1

Mechanics and Materials

Overview of MEMS and Microsystems – Thin film growth and models –Mechanical, Electrical, Thermal properties for Thin Films/MEMS –Measurement techniques – Materials for MEMS- Semiconductors, Metals and Metal alloys, Ceramics, Polymers – Silicon and other substrate materials.

Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Module-2

Processing of MEMS/NEMS and Microsystems

Silicon processing, Structure & properties – Single crystal growth - Overview of Lithographic process – Additive processes for Semiconductors, Ceramics, Metals and polymers - MEMS Fabrication – Doping process - Bulk micromachining - Wet & Dry Etching- Isotropic and anisotropic etching and mechanism - Etch stop techniques – DRIE and other processes- Surface Micromachining – LIGA and laser assisted processing – Nanomechanical system fabrication - Fundamentals of Design and Simulation

Teaching-Learning Process	.Chalk and talk method / PowerPoint Presentation

Module-3

Interconnects and Bonding

Interconnects – requirements of interconnects –Metallization Techniques — Damascene process- silicide and refractory metals - Multilevel and nanostructured interconnects – Bonding Techniques.

Packaging and Failure: Packaging Fundamentals – Packaging Techniques– Electrical and thermal requirements - Packaging Reliability and failure modes and analysis – MEMS process integration- Tribological issues

Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Module-4

Engineering Mechanics

Microsystem design – Static bending of thin films –Mechanical vibration– thermomechanics–fracture mechanics – Thermofluidics

Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Module-5

Design and Applications

Scaling laws in miniaturization – Design considerations – Process and Mechanical design – Finite element method (FEM), Computer aided design CAD – Mircosensors and Microactuators– Optical, chemical, thermal, gas, pressure, bio and mechanical sensors – Nanosensors–Applications in automobile, aerospace, health care, industrial, consumer and telecommunications

Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Tai-Ran Hsu, MEMS and Microsystems – Design, Manufacture, and Nanoscale Engineering, Second Edition, John Wiley & Sons, Inc., New Jersey, 2008, ISBN: 978-0-470-08301-7.

2. Reza Ghodssi, Pinyen Lin, MEMS Materials and Processes Handbook, Springer, New York, 2011, ISBN: 978-0-387-47316-1.

3. Nadim Maluf and Kirt Williams, An introduction to Micro electro mechanical systems Engineering, Second Edition – Artech House, Inc., Boston, 2004, ISBN: 1-58053-590-9.

4. Sami Franssila, Introduction to Microfabrication, Second Edition, John Wiley & Sons, Sussex, 2010, ISBN: 978-0-470-74983-8.

5. Marc Madou, Fundamentals of Microfabrication, Second Edition, CRC Press, Boca Raton, 2002, ISBN: 0-8493-0826-7.

6. Francisco J. Arregui, Sensors based on nanostructured materials, First Edition, Springer-Verlag, New York, 2009, ISBN: 978-0-387-77752-8.

7. Bharath Bhushan, Springer Hand Book of Nano Technology, Third Edition, Springer-Verlag, New York, 2010, ISBN: 978-3-642-02524-2.

8. Sergey Edward Lysherski, MEMS and NEMS Systems, devices, and structures, First Edition, CRC Press, Boca Raton, 2002, ISBN: 9780849312625.

9. H. Baltes, O. Brand, G. K. Fedder, C. Hierold, J. G. Korvink, O. Tabata, Enabling Technology for MEMS and Nanodevices, Wiley-VCH, Weinheim, 2013, ISBN: 978-3-527-33498-8..

10. Danny Banks, Microengineering, MEMS, and Interfacing - A Practical Guide, Taylor & Francis, Boca Raton, 2006, ISBN: 978-0-8247-2305-7.

11. C.P. Wong, Kyoung-Sik (Jack) Moon, Yi Li, Nano-Bio- Electronic, Photonic and MEMS Packaging, Springer, New York, 2010, ISBN: 978-1-4419-0039-5.

12. Sandra Carrara, Nano-Bio-Sensing, Springer, New York, 2011, ISBN: 978-1-4419-6169-3.

Web links and Video Lectures (e-Resources):

- Introduction to MEMS & Microsystems: Prof. Santiram Kal, IIT Kharagpur: https://www.youtube.com/watch?v=j9y0gfN9WMg
- Application of MEMS, Prof. Santiram Kal, IIT Kharagpur: https://www.youtube.com/watch?v=JW7zZyFVpGM
- MEMS Fabrication Techniques: https://www.youtube.com/watch?v=f7KKd292WMQ
- Silicides and Copper Metallization: https://www.youtube.com/watch?v=eJF5Ot3HADU
- What is sensor: Its Types and Applications: https://www.youtube.com/watch?v=ht-_RmhLD7k

Skill Development Activities Suggested

- Assignments
- Quizes
- Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Demonstrate the knowledge of the basics and develop applications for microsystems	Apply
CO2	Operate MEMS transducers	Apply
CO3	Implement applications of electrostatics in MEMS sensors and actuators	Apply

Program Outcome of this course

Sl. No.	Description	POs
1	Engineering knowledge	1
2	Problem analysis	2
3	Design/development of solutions	3
4	Conduct investigations of complex problems	4
5	Modern tool usage	5

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x	x	x	x	x							
CO2	x	x	x	x	x							
CO3	x	x	x	x	x							

Semester- II

NANOCOMPOSITES AND THEIR APPLICATIONS			
Course Code	**MNST216B**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To give an overview of Nanocomposites and properties.
- To learn about various nanostructures to be used in designing Nanocomposites.
- To understand the applications Nanocomposites in industry

Module-1

Introduction to nanocomposites

Definition of composite material, Classification based on matrix and topology, Constituents of composites, Interfaces and Interphases, Distribution of constituents, Nano-composites. Advantage of composite materials, mechanical properties, Thermal, electrical and electronic and optical properties. Super hard nanocomposites-designing and mechanical properties - stress-strain relationship, toughness, strength, and plasticity.

Module-2

Ceramic metal nanocompsites

Ceramic based nanoporous composites, metal matrix nanocomposites, natural nano-bioccomposites, bio-mimetic nanocompostes and biologically inspired nanocomposites, nanocompsites for hard coatings, DLC coatings, thin film naocomposites, modelling of nanocomposites, synthesis of various nanocomposites materials, sputtering, mechanical alloying.

Module-3

Polymer nanocomposites

Introduction to polymer composites, Processing of nanoparticles, binding mechanisms in nanoparticles, dispersion of nanoparticles, and stabilization of nanoparticles. Processing and fabrication of polymer nanocomposites, Melt blending, solvent casting, In-situ polymerization, solution polymerization, template synthesis, high shear mixing. Homogeneous/heterogeneous nucleation, plasma promoted nucleation. Polymer nanocomposites with structural, gas barrier and flame retardant properties, carbon fibre reinforced polymer composites, elastomer and thermoplastic elastomer nanocomposites for propulsion systems, water borne fire-retardant nanocomposites, hybrid composites for cosmetics, protective and decorative coatings.

Module-4

Natural nanocomposite systems

Spider silk, bones, shells; organic–inorganic nanocomposite formation through self-assembly. Biomimetic synthesis of nanocomposite material; use of synthetic nanocomposites for bone teeth replacement. Bioactive nanocomposites in bone grafting and tissue engineering, inorganic/polymer nanocomposites for dental restoration and bone replacement applications.

Module-5

Bio ceramics for implant coating

Calcium phosphates-hydroxyapatites Ti_6Al_4V and other biomedical alloys, implant tissue interfacing-metal organic CVD-use of tricalcium phosphate-biomimetic and solution based processing- osteoporosis- osteo plastic, regeneration of bones by using bio compatible ceramics, bio interactive hydro gels- PEG coating and surface modifications, PEG hydrogels patterned on surfaces- PEG based hydrogels.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

TEXT BOOKS:

1. Nanocomposite science and technology by P.M.Ajayan, L.S. Schadler and P.V. Braun, Wiley-VCH GmbH Co. 2003.
2. Encyclopedia of Nanotechnology by H.S.Nalwa, American Scientific Publishers, 2003.
3. Metalopolymer nanocomposites, Ed A.D. Pomogailo and V.N.Kestelman, Springer-Verlag, 2005.
4. Composite materials, K.K. Chawala, 2nd ed., (1987) Springer-Verlag, New York.

References:

1. Biomedical nanostructures by Kenneth E.Gonsalves, Craig R. Halberstadt, Cato T. Laurencin, Lakshmi S. Nair. John-Wiley & Sons, 2008.
2. Nanobiotechnology II: Edited by Chad A. Mirkin and Christof M. Niemeyer, Wiley-VCH, 2006.
3. Handbook of Biomineralization: Biomimetic and Bioinspired, Chemistry edited by Peter Behrens, Edmund Bäuerlein John-Wiley Sons, 2006.3. Steven S Saliterman, Fundamentals of BioMEMS and Medical Microdevices, 2006

Web links and Video Lectures (e-Resources):

- Nanocomposites: Prof. A. K. Ganguli, IIT Delhi: https://www.youtube.com/watch?v=t-pVi3IMdOk
- Overview: nanoceramic composites: Prof. B. V. Manoj Kumar, IIT Roorkee: https://www.youtube.com/watch?v=CJn2gXp3pyo
- Polymer Matrix and Nano Composites, Dr. J. Ramkumar, IIT Kanpur: https://www.youtube.com/watch?v=Gtzin_hz9pE
- Introduction to Biomimicry: IITM: https://www.youtube.com/watch?v=Of-sdUpMgsg
- Introduction to Biomaterials, Prof. Bikramjit Basu, IIT Kanpur, Processing of Bioceramics: http://www.infocobuild.com/education/audio-video-courses/materials-science/IntroductionToBiomaterials-IIT-Kanpur/lecture-19.html

Skill Development Activities Suggested

- Assignments
- Quizes
- Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Design different types nanostructures that are suitable to specific application.	Design
CO2	Demonstrate a knowledge of polymer based nanocomposites and its applications.	Apply
CO3	Analyze the properties of polymer Nanocomposites and their behavior depending on the type of nanomaterials.	Apply

Program Outcome of this course

Sl. No.	Description	POs
1	Engineering knowledge	1
2	Problem analysis	2
3	Design/development of solutions	3
4	Conduct investigations of complex problems	4

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x	x	x	x								
CO2	x	x	x	x								
CO3	x	x	x	x								

Semester- II

INDUSTRIAL APPLICATIONS OF NANOTECHNOLOGY			
Course Code	**MNST216C**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

1. To elucidate on advantages of nanotechnology based applications in each industry.
2. To provide instances of contemporary industrial applications of nanotechnology.
3. To provide an overview of future technological advancements and increasing role of nanotechnology in each industry

Module-1

Nanotechnology in Electrical and Electronics Industry

Advantages of nano electrical and electronic devices –Electronic circuit chips – Lasers - Micro and Nano-Electromechanical systems – Sensors, Actuators, Optical switches, Bio-MEMS –Diodes and Nano-wire Transistors - Data memory –Lighting and Displays – Filters (IR blocking) – Quantum optical devices – Batteries - Fuel cells and Photo-voltaic cells – Electric double layer capacitors – Lead-free solder – Nanoparticle coatings for electrical products

Module-2

Nanotechnology in Biomedical and Pharmaceutical Industry

Nanoparticles in bone substitutes and dentistry – Implants and Prosthesis - Reconstructive Intervention and Surgery – Nanorobotics in Surgery – Photodynamic Therapy - Nanosensors in Diagnosis– Neuro-electronic Interfaces – Protein Engineering – Drug delivery – Therapeutic applications.

Module-3

Nanotechnology in Chemical Industry

Nanocatalyts – Smart materials – Heterogenous nanostructures and composites – Nanostructures for Molecular recognition (Quantum dots, Nanorods, Nanotubes) – Molecular Encapsulation and its applications – Nanoporous zeolites – Self-assembled Nanoreactors - Organic electroluminescent displays

Module-4

Nanotechnology in Agriculture and Food Technology

Nanotechnology in Agriculture -Precision farming, Smart delivery system – Insecticides using nanotechnology – Potential of nano-fertilizers - Nanotechnology in Food industry - Packaging, Food processing - Food safety and bio-security – Contaminant detection – Smart packaging

Module-5

Nanotechnology In Textiles And Cosmetics

Nanofibre production - Electrospinning – Controlling morphologies of nanofibers – Tissue engineering application – **Polymer nanofibers** - Nylon-6 nanocomposites from polymerization - Nano-filled polypropylene fibers - **Bionics**– Swim-suits with shark-skin-effect,Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, antibacterial, hydrophilic, self-cleaning, flame retardant finishes) – **Modern textiles** (Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof, Cleaner kids clothes, Wired and Ready to Wear)

Cosmetics – Formulation of Gels, Shampoos, Hair-conditioners (Micellar self-assembly and its manipulation) – Sun-screen dispersions for UV protection using Titanium oxide – Color cosmetics.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

1. Mark A. Ratner and Daniel Ratner,Nanotechnology: A Gentle Introduction to the Next Big Idea, Pearson (2003). 10 NT – 12–13 – SRM – E&T
2. Bharat Bhushan,Springer Handbook of Nanotechnology, Barnes & Noble (2004).
3. Neelina H. Malsch (Ed.),Biomedical Nanotechnology, CRC Press (2005)

References:

1. Udo H. Brinker, Jean-Luc Mieusset (Eds.), Molecular Encapsulation: Organic Reactions in Constrained Systems,Wiley Publishers (2010).
2. Jennifer Kuzma and Peter VerHage, Nanotechnology in agriculture and food production, Woodrow Wilson International Center, (2006).
3. Lynn J. Frewer, WillehmNorde, R. H. Fischer and W. H. Kampers, Nanotechnology in the Agri-food sector, Wiley-VCH Verlag, (2011).
4. P. J. Brown and K. Stevens, Nanofibers and Nanotechnology in Textiles, Woodhead Publishing Limited, Cambridge, (2007).
5. Y-W. Mai,Polymer Nano composites, Woodhead publishing, (2006).
6. W.N. Chang, Nanofibres fabrication, performance and applications, Nova Science Publishers Inc, (2009).

Web links and Video Lectures (e-Resources):

- Introduction to Nanoelectronics, IISc Bengaluru: https://www.youtube.com/watch?v=wdNFCWLuC10
- Biomedical nanotechnology, https://www.digimat.in/nptel/courses/video/102107058/L01.html
- Heterogeneous Nanocatalysis: IIT Gandhinagar: https://www.youtube.com/watch?v=bNtTfGPfy_Y
- Nanotechnology in Agriculture - Prof Mainak Das, IIT Kanpur: https://www.youtube.com/watch?v=hdDBvC7kop8
- Nanofibers: https://www.youtube.com/watch?v=i-EmUjv-fL4

Skill Development Activities Suggested

- Assignments
- Quizes
- Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Demonstrate the knowledge of various industrial applications of nanotechnology.	Apply
CO2	Classify future technological advancements and increasing role of nanotechnology in each industry	Analyze

Program Outcome of this course

Sl. No.	Description	POs
1	Engineering knowledge	1
2	Problem analysis	2
3	Design/development of solutions	3
4	Conduct investigations of complex problems	4
5	Modern tool usage	5
6	The engineer and society	6
7	Environment and sustainability	7
8	Ethics	8
9	Life-long learning	12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x	x	x	x	x		x					
CO2	x	x	x	x	x	x	x	x				x

Semester- II

NANOMATERIALS AND DRUG DELIVERY			
Course Code	**MNST216D**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

1. This course provides an overview of the underlying principles of Nanomaterial based drug delivery systems.
2. Understand the application of nanostructures as drug delivery systems.
4. Nanoparticles based drug formulation for cancer therapy and bioimaging application.

Module-1

Importance nanomaterials in drug delivery, Modes of drug delivery, advantages and disadvantages, controlled and targeted drug delivery and its importance.

Nano sized Drug Carriers

Structure, Preparation and application as drug carriers: Liposomes, Cubosomes and Hexosomes, Solid Lipid Nanoparticles (SLP), Lipid based colloidal system, Dendrimer (PAMAM), Polymer Micelle, Ceramic and Magnetic nanoparticle, Polymer drug conjugates. Multifunctional Drug carriers, organic and inorganic composites.

Module-2

Smart Nanomaterials for Drug delivery Applications

Definition and importance of smart materials, stimuli and response, Physical responsive nanomaterials: Electrical, Electrochemical, Light and Magnetic responsive nanomaterials. Chemical responsive Nanomaterials: pH, Redox, Biological, Glucose, Enzyme, Dual and multi responseive nanomaterials.

Carbon based nanomaterials: Graphene, Carbon nanotubes and Fullerenes in drug delivery applications and their biocompatibility.

Module-3

Drug Discovery & Cancer therapy using nanomaterials and technology

Drug Discovery Using Nanocrystals, Drug Discovery Using Resonance Light Scattering (RLS) Technology. Nanosensors in Drug Discovery, Drug Delivery Applications, Nanorobots, Benefits of Nano-Drug Delivery. Use of microneedles and nanoparticles for local highly controlled drug delivery. Metal nanoparticles in drugs discovery. Nanotechnology for Cancer therapy-Nanobodies, Nanoparticles, nanoshells, Nanobombs, pebbles for brain tumor therapy, Targeting through angiogenesis and Folate Receptors Liposomal formulation in cancer therapy.

Module-4

Nanomedicines

Introduction, Applications of nanobiotechnology in medicine, Role of nanotechnology in methods of treatment, Nanomedicines for Nervous system, Developing Nanomedicines, Protocols for nanodrug Administration, Nanotechnology in Diagnostics applications, materials used in Diagnostics and Therapeutic applications-Molecular Nano mechanics, Molecular devices, Nanomedicines for Skin disorders, wound healing, eye diseases, infections, Nanotubes for detection and destruction of bacteria.

Module-5

Nanomaterials and technology in bioanalytics

Nanoparticles for biological labelling, Nano-Imaging Agents, Nano particles molecular labels,

Immuno gold- silver staining, combined fluorescent and gold probes, Protein Labeling, gold cluster labelled peptides, gold cluster conjugates of other small molecules, gold-lipids metallosomes, Larger covalent particles labels, gold cluster nanocrystals.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

TEXT BOOKS:

1. Nanotechnology in Drug Delivery: Melgardt M. de Villiers, PornanongAramwit, glen s. Kwon, Springer, 2009
2. NanoBiotechnology: BionInspired Devices and Materials for the Future: OdedShoweyov, Ilan Levy, Humana Press, New Jersey 2010
3. Nanobiotechnology, Concepts applications and Perspectives: C. M. Niemeyer and Chad A. Mirkin, Wiley VCH, 2009

Reference books:

1. Bionanotechnology Global prospects II: david E Reisner, CRC Press 2012
2. Nanoparticulate Drug Delivery Systems Deepak Thassu, Michel Deleers (Editor), Yashwant Pathak
3. Drug Delivery and Targeting, A.M.Hillery, CRC Press, 2002.
4. Bio-Applications of Nanoparticles Warren C.W. Chan
5. Lisa Brannon-Peppas, James O. Blanchette Nanoparticle and targeted systems for cancer therapy Advanced Drug Delivery Reviews 56 (2004) 1649– 1659

Web links and Video Lectures (e-Resources):

1. **NPTEL drug delivery principles: https://archive.nptel.ac.in/courses/102/108/102108077/**
2. **Nanoparticles for drug delivery: https://youtu.be/f7hMhL_N4k8**
3. **Nanoparticles for cancer therapy https://youtu.be/emEua2eJp1U**
4. **Nano imaging: https://youtu.be/I3_M3e2ZiE8**
5. **Nanomedicine: https://youtu.be/nWZDLOKgAN8**
6. **Drug discovery: https://youtu.be/TXNeWkbVaGE**
7. **Cancer Therapy : https://youtu.be/OxSDfCXNxo8**
8. **Nanodrug delivery systems: https://youtu.be/5BOi13cytTY**

Skill Development Activities Suggested

- Assignments
- Quizes
- Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	BloomsLevel
CO1	Demonstratetheknowledgeto developnanoparticlebased newtypesofbiomedicalmarkersand therapeuticagents.	Apply
CO2	Evaluatethe suitablenanostructurefor drugdeliverysystems application.	Apply

Program Outcome of this course

Sl. No.	Description	POs
1	Engineeringknowledge	1
2	Problemanalysis	2
3	Design/developmentofsolutions	3
4	Conductinvestigationsofcomplex problems	4
5	Modern tool usage	5
6	Ethics	8
7	Individual and team work:	9
8	Communication	10
9	Life long learning	12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x	x	x	x	x			x	x	x		x
CO2	x	x	x	x	x			x	x	x		x

Semester- II

NANO MATERIALS AND TECHNOLOGY IN FOOD AND AGRICULTURE			
Course Code	**MINT215E**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	03

Course Learning objectives:

- *To provide students the opportunity to learn the most recent advances in agriculture nanotechnology*
- To train the students in application aspects of nanotechnology in food and agriculture fields
- Explore the role of Nanotechnology in Food Processing

Module-1

Agricultural Nanotechnology:

Conventional Farming: Issues and Limitations, Intensive Conventional Farming Affects Environment,

Current Agricultural Production Systems, Nanotools -Nano processes, and Nanomaterials Production of Bionanomaterials from Agricultural Wastes**:** Cellulose and Nanocellulose from Citrus and Orange

Wastes, Synthesis of Graphene Oxide from Agro wastes, Production of Amorphous Silica Nanoparticles from Agrowastes, Carbon Nanomaterials from Agrowastes,

Module-2

Nanoengineering Superabsorbent Materials in Agriculture:

Introduction, Formation and Structure of Cross-Linked Polyacrylates, Formation and Structure of Cross-Linked Polyacrylates; Statistical Models, Mechanisms of Swelling in Superabsorbent Polymers, Mechanisms of Swelling in Superabsorbent Polymers; Hydration, Hydrogen Bonds, Properties of Superabsorbent Polymers, Absorption of Aqueous Solution, Moisture Absorption Superabsorbent Polymers Application in Agriculture Superabsorbent/Clay

Module-3

Nanotechnology in plant protection:

Nanotechnology and Their Applications in Insect's Pest Control; Formulations of Nanoinsecticides-

Nanoemulsions, Components, Preparation, Types and Methods, Nanoparticle-Based Plant Disease

Management; Interactions between NPs, Pathogens, and Plants, Plant Disease Diagnosis Using different NPs, Nanotechnology in Microbial Plant Pathogen and insect Management, Targeted Delivery of Agrochemicals Using Nanotechnology, Nanobased Pesticides in Agriculture, Nano-based Fertilizer Efficiency, Improving Plant Traits against Environmental Stresses Using Nanotechnology, Nanotechnology and Its Applications in Water Conservation

Module-4

Nanoparticles in food production and diagnostics:

Food and New Ways of Food Production - Efficient Fractionation of Crops Efficient Product Structuring -Optimizing Nutritional Values - Applications of Nanotechnology in Foods: Sensing, Packaging, Encapsulation, Engineering Food Ingredients to Improve Bioavailability - Nanocrystalline

Food Ingredients - Nanoemulsions - Nano-Engineered Protein Fibrils as Ingredient Building Blocks

Preparation of Food Matrices - Concerns about Using Nanotechnology in food production. Diagnostics Enzyme Biosensors and Diagnostics - DNA- Based Biosensors and Diagnostics Radiofrequency Identification- Integrated Nanosensor Networks: Detection and Response- Lateral Flow (Immuno) assay - Nucleic Acid Lateral Flow (Immuno)assay - Flow-Through

(Immuno)assays - Antibody Microarrays Surface Plasmon Resonance Spectroscopy.

Module-5

Nanotechnology in food packaging:

Crop improvement - Reasons to Package Food Products - Physical Properties of Packaging Materials -Strength - Barrier Properties Light Absorption – Structuring of Interior Surfaces - Antimicrobial
Functionality - Visual Indicators – Quality Assessment - Food Safety Indication - Product Properties -
Information and Communication Technology - Sensors -Radiofrequency Identification Technology-
Risks - Consumer and Societal Acceptance

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**
CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1) Nanobiotechnology Applications in Plant Protection by Kamel A. Abd-Elsalam and Ram Prasad, Volume 2, Springer, 2018.
2) Nanotechnology an Agricultural Paradigm by Ram Prasad, Manoj Kumar, Vivek Kumar Springer, 2017.
3) Nanoscience in Food and Agriculture by Shivendu Ranjan, Volume 1, Springer, 2016.
4) Nanotechnology and Plant Sciences by Manzer H. Siddiqui, Springer, 2015.
5) Nanoparticle Assemblies and Superstructures by Nicholas A. Kotov, CRC, 2006.
6) Nanotechnology in agriculture and food production by Jennifer Kuzma and Peter VerHage, Woodrow Wilson International, 2006.
7) Bionanotechnology by David S Goodsell, John Wiley & Sons, 2004.
8) Nanobiomaterials Handbook by Balaji Sitharaman, Taylor & Francis Group, 2011.

Web links and Video Lectures (e-Resources):

1) . **NPTEL Course on Nanotechnology in agriculture** https://youtu.be/hdDBvC7kop8
2) **NPTEL Course on Nanotechnology in Food processing** https://www.youtube.com/watch?v=DOAo7LtwXlQ

Skill Development Activities Suggested

- Assignments
- Quizes
- Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Lev
CO1	Explain concepts of nanotechnology in food packaging and processing	Comprehens and evaluati
CO2	Demonstrate the applications of nanotechnology in agriculture industry	Apply

Program Outcome of this course

Sl. No.	Description	POs
1	Engineering knowledge	1
2	Problem analysis	2
3	Design/development of solutions	3
4	Conduct investigations of complex problems	4
5	Modern tool usage	5
6	The engineer and society	6
7	Environment and sustainability	7
8	Ethics:	8
9	Individual and teamwork:	9
10	Communication	10
11	Lifelong learning	12

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x	x	x	x	x	x	x	x	x	x		x
CO2	x	x	x	x	x	x	x	x	x	x		x

Semester- II

ADVANCED AND SMART MATERIALS			
Course Code	**MINT215F**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- The course aims at providing overview of latest development in the Advanced and Smart materials.
- Introduce concepts and principle behind the materials property
- Analyze the potential different nanomaterials for their application

Module-1

Photonic Materials: Need for New Photonic Materials, composite materials for nonlinear optics, nanostructured waveguides for nonlinear optics quantum and nonlinear optics for advanced imaging applications. Nanophotonics—An Exciting Frontier in Nanotechnology. Nanophotonics at a Glance.

Module-2

Spintronic Materials: Modelling the growth of Mn on semiconductor substrates, Dilute magnetic semiconductor nanocrystals, Advances in wide bandgap materials for semiconductor spintronics

Module-3

Plasmonics: Metallic Nanoparticles and Nanorods, Metallic Nanoshells. Local Field Enhancement, Subwavelength Aperture Plasmonics, Plasmonic Wave Guiding. Applications of Metallic Nanostructures. Radiative Decay Engineering.

Module-4

Smart Materials

Thermoresponsive materials, piezoelectric materials, electrostrictive and magnetostrictive materials, Polychromic, Chromogenic or Halochromic Materials

Module-5

Magnetic materials, superparamagntism in metallic nanoparticles, Giant and colossal magnetic materials, ferrofluids, ER and MR fluids, biomimetic materials, smart gel, shape memory alloys and polymers

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

.

Suggested Learning Resources:

TEXT BOOKS:

1. Introduction to Solid State Physics, C. Kittel, Wiley Eastern
2. A practical approach to X-Ray diffraction analysis by C.Suryanarayana
3. Semiconductor Physics, P. S. Kireev, MIR Publishers.

References:

1. Solid State Physics, A. J. Dekkar, Prentice Hall Inc.
2. Introduction to Superconductivity, M. Tinkham, McGraw-Hill, International Editions
3. Elementary Solid State Physics: Principles and applications, M. A. Omar, Addison-Wesley.
4. Advanced Materials in Catalysis, Frank Bolz, Academic Press, 1977

Advanced Healthcare Materials Tiwari, A. (ed) (2014), John Wiley & Sons, Inc., Hoboken, NJ, USA.

Web links and Video Lectures (e-Resources):

- Integrated Photonics Devices and Circuits, IITM: https://www.youtube.com/watch?v=xasZDwgSFiE
- Spintronic Materials, Colossal Magentoresistive Oxides: https://www.youtube.com/watch?v=ABZz--4XkNs
- Plasmonic nanoparticles, IIT Bombay: https://www.youtube.com/watch?v=cWOFsv4a8sU
- Introduction to Smart Materials: https://www.youtube.com/watch?v=76QWN1tY8fo
- Magnetic materials, IIT Kanpur: https://www.youtube.com/watch?v=6QUFuZpCgGw

Skill Development Activities Suggested

- Assignments
- Quizes
- Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Interpret smart materials for applications related with safe societal needs	Understand
CO2	Demonstrate advanced material's engineering applications in thermal, magnetic, spintronic, and electronics based devices	Apply

Program Outcome of this course

Sl. No.	Description	POs
1	Engineering knowledge	1
2	Problem analysis	2
3	Design/development of solutions	3
4	Conduct investigations of complex problems	4
5	Modern tool usage	5
6	Ethics	8
7	Life-long learning	12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x	x						x				x
CO2	x	x	x	x	x							

Semester- II

NANO MATERIALS AND TECHNOLOGY IN BIOMEDICAL APPLICATIONS			
CourseCode	**MINT215G**	CIEMarks	50
TeachingHours/Week(L:P:SDA)	2:0:2	SEE Marks	50
TotalHoursofPedagogy	40	TotalMarks	100
Credits	3	ExamHours	3

CourseLearningobjectives:

- This course provides an overview on the various aspects of surface interactions with liquid-solid-gasenvironment.
- Itprovidesaselectiveunderstandingonthesurfacephenomenoninvolvedinmechanical,electrical,optical, andbiologicalworld.
- Thiscourseprovidesanother dimensioninthesurfaceunderstanding–foreg.,to lookintothe mechanical aspectsin thebioworld

Module-1

Bio ceramics for implant coating: calcium phosphates - hydroxy epilates Ti6Al4V and other biomedical alloys - implant tissue interfacing – metal organic CVD – use of tricalcium phosphate – biomimetic and solution based processing – osteo porosis – osteo plastic – regeneration of bones by using bio compactable ceramics – biointeractive hydro gels – PEG coating and surface modifications – PEG hyrogels patterned on surfaces – PEG based hyrogels

Module-2

Tissue Engineering : scaffolds for tissue fabrications – materials for scaffolds – materials for hydrogel scaffolds – scaffolds fabrications technologies – textile technologies – particulate –leaching techniques – phase separation – design of three-dimensional pore architecture – nano-featured and bioactive scaffolds – nano-fiber scaffolds – nanocomposite scaffolds – bioactive scaffolds – scaffolds for stem cells – micro and nanopatterned scaffolds - scaffolds and stem cells – Engineering biomaterial to control cell function – building structure into engineered tissues – fibrous proteins and tissue engineering .

Module-3

Nanomedicine: Diagnosis of diseases, treating and preventing of diseases – targeted for drug delivery – ligand coupled nanoparticle features – methods for coupling targeting ligands to nanoparticles – targeting modalities – barriers to tumor targeting *in vivo* – MRI contrast enhancement - future line of action – Gene delivery – Bio molecular motors - Nanoscale transport systems: molecular shuttle powered by Biomolecular motors

Module-4

Nanopharmacy: multi-targeted drugs – delivery of nucleic acids- barriers to therapeutic applications – interaction of organic molecules of the drug with pathological tissue – ligand targeted nanoparticles drug delivery: combining multiple functions - formation of nucleic acid core particle – protective steric coating – surface exposed ligands targeting specific tissues –biocompatible core-shell nanoparticles for medicine – configuration of core – shell structure with different cores, shells and biomolecules-least toxicity-nanocapsules-methods of changing surface characteristics- future prospects.

Module-5

Medical Devices: Imaging, implantable sensors, cell specific gene therapy, DNA chips and micro arrays, Surface immobilized protein nano structures Forensic Applications: Collection and analysis of evidence of different types of crime scenes including drugs, DNA analysis, blood splattering, serology, toxicology DNA nanotechnology DNA origami Application of DNA nanotechnology Drawbacks of DNA origami. Protein nanotechnology & applications. Glyco nanotechnology & applications. DNA nanomachines Protein nanomachines Demonstration of motility of bacteria Nanomachine communication

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

SuggestedLearningResources:

TEXT BOOKS:

1. Nanotechnology in Drug Delivery: Melgardt M. de Villiers, PornanongAramwit, glen s. Kwon, Springer, 2009
2. NanoBiotechnology: BionInspired Devices and Materials for the Future: OdedShoweyov, Ilan Levy, Humana Press, New Jersey 2010
3. Nanobiotechnology, Concepts applications and Perspectives: C. M. Niemeyer and Chad A. Mirkin, Wiley VCH, 2009
4. DNA Arrays: Technologies and experimental strategies ed. E.V. Grigorenko, CRC Press 2002.
5. Robert.W.Kelsall, Ian.W.Hamley, Mark Geoghegan, Nano Scale Science And Technology, John Wiley and son, ltd., 2005

Reference books:

1. Robert.W.Kelsall, Ian.W.Hamley, Mark Geoghegan (Ed), Nano Scale Science And Technology, John Wiley and son, ltd., 2005
2. H.Fujita (Ed), Micromachines As Tools For Nanotechnology, Springer, 2003
3. Mick Wilson Kamali Kannangara Geooff Smith Michelle, Simmons Urkhard Raguse, Nano Technology, Overseas India private Ltd., 2005.
4. Gunter Schmid , Nano Particles, Jhon wiley and sons limited, 2004
5. K.K.Jain, Nano Biotechnology, Horizions Biosciences, 2006

WeblinksandVideoLectures(e-Resources):

1. **Biomedical Nanotechnology: https://nptel.ac.in/courses/102107058**
2.

SkillDevelopmentActivitiesSuggested

- Assignments
- Quizes
- Seminars

Courseoutcome(CourseSkill Set)

At theend ofthe coursethestudent willbeable to:

Sl. No.	Description	BloomsLevel
CO1	Demonstratetheknowledgeon state-of-the-art and future nanotechnologies used for medical and biological science applications	Apply
CO2	Evaluatethe suitablenanostructurefor drugdeliverysystems application.	Apply

ProgramOutcomeof thiscourse

Sl. No.	Description	POs
1	Engineeringknowledge	1
2	Problemanalysis	2
3	Design/developmentofsolutions	3
4	Conductinvestigationsofcomplex problems	4
5	Moderntoolusage	5
6	Life long learning	12

MappingofCOSandPOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x	x	x	x	x							x
CO2	x	x	x	x	x							x

Semester- II

ADVANCES IN NANODEVICES			
Course Code	**MINT216E**	CIE Marks	50
Teaching Hours/Week(L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	3

Course Learning Objectives:

1. To give an overview to the students about advances in nanodevices which are the critical tools for electronic, magnetic, mechanical, and biological systems.
2. To prepare students for these devices applications in energy conversion, controlling pollution, producing food, and improving human health and longevity.

Module-1

NANODEVICES-AN INTRODUCTION:

Definition Classification of Nanodevices: Electrical nanodevices, Magnetic nanodevices, Biological nanodevices, and Mechanical nanodevices. Nanodevices based on ballistic transport, Nanodevices based on Tunneling, Electrostatic nanodevices, Magnetostatic nanodevices, Spin nanodevices, Molecular electronics

Module-2

NANODEVICES BASED SYSTEMS

A classification of nanomaterials for Nanoordered system: 3D, bulk materials, 2D, thin film or well or sheet a few atoms thick,1D, nanowire or nanotube, 0D, quantum dot.

Silicon Nanowire Biochemical Sensors: Fabrication of Nanowires, Functionalization of nanostructure devices for biomolecular detection, Sensitivity of Silicon Nanowire,Biochemical Sensors, Integration of Silicon Nanowires with CMOS, Portable, Integrated Lock-in-Amplifier- Based System for Real-Time Impedimetric Measurements on Nanowires Biosensors

Module-3

SEMICONDUCTOR NANODEVICES:

Introduction to Semiconductors, Classification of semiconductors: chemical composition, Classification of semiconductors: nature of charge carriers, Electrical conduction in semiconductor. Semiconductor nanodevices: p-n diode, BJT, MOSFET, ICs, LED, and solar cell**.**

Module-4

Silicon based semiconductor device fabrication: Historical overview all process technology, Brief summary of Integrated circuits (ICs) such as computer processors, microcontrollers, and memory chips. Feature size: technology node or process node by minimum feature size in nanometres, device tests, device yield, die preparation, packaging, System on Chip.

Module-5

Nanodevices applications

III-V Semiconductor Nanowire-based Solar Cells, New Materials, Devices and Technologies for Energy Harvesting and RF applications, General Synthetic Strategies for III-V Nanowires, Graphene and 2D Layer Devices for More Moore and More-than-Moore Applications.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books:

1. Nanodevices. Principle and Applications, Jaysukh Marknaand Tulshi Shiyani, ISBN (Book) 9783346002099, GRIN Verlag, 2018
2. Advances in III-V Semiconductor Nanowires and Nanodevices, Edited By Jianye Li et al, Bentham Science Publishers Ltd., 2011.
3. Beyond-CMOS Nanodevices 1&2, Edited by Francis Balestra, Wiley, 2014.

Reference Books:

Dekker Encyclopedia of Nanoscience and Nanotechnology, 3rd edition, Seven Volume Set, by Sergey Edward Lyshevski (Editor), ISBN-13: 9781439891346, CRC Press, 2014.

Weblinks and Video Lectures(e-Resources):

1. Nanodevices: https://youtu.be/PyHRtR4y6x0
2. Nanodevices Navakant Bhat: https://youtu.be/P80knT7Eq94

Skill Development Activities Suggested

- Assignments
- Quizes
- Seminars

Course outcome(Course Skill Set)

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

Sl. No.	Description	BloomsLevel
CO1	Explain nanoscale device fab and applications	Comprehension and evaluation
CO2	Design, Test and Evaluate nanoscale device.	Evaluation

Sl. No.	Description	POs
1	Engineering knowledge	1
2	Problem analysis	2
3	Design/development of solutions	3
4	Conduct investigations of complex problems	4
5	Modern tool usage	5
6	Individual and Team work	9
7	Communication Skills	10

Program Outcome of this course

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x	x	x	x	x				x	x		
CO2	x	x	x	x	x				x	x		

Semester- II

SURFACE ENGINEERING OF NANOMATERIALS			
Course Code	**MINT216F**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- This course provides an overview on the various aspects of surface interactions with liquid-solid-gas environment.
- It provides a selective understanding on the surface phenomenon involved in mechanical, electrical, optical, and biological world.
- This course provides another dimension in the surface understanding – for eg., to look into the mechanical aspects in the bio world

Module-1

Introduction to Surfaces

Surfaces and Interfaces – Importance of Surfaces in Nano Regime – Thermodynamics of surfaces – surface energy – notation of surface structures – surface reconstruction -Surface and interfacial tension and measurement– contact angle and wetting – surfactants, and interfacial forces – Review of Surface Characterization Techniques – optical, topographic, chemical and mechanical properties (XPS, PIXE, RBS, SIMS, LEED, RHEED)

Module-2

Processes at Solid Surfaces

Adsorption – Physisorption and Chemisorption – Adsorption isotherms (Langmuir and BET) – Reaction Mechanism (Langmuir-Hinshelwood and Eley-Rideal) – Sticking Probability –Types of Catalyst – Homo vs Hetero - Properties and preparation of Catalyst – TON, TOF, E factor - Surface and electronic properties of metal and metal oxide catalyst and its principle behind catalysis – Sabatier Principle – Bronstedt – Polanyi relation - Role of Surfaces, Interfaces, Morphology in Catalysis– Active sites incatalysis & determination – porous materials and supported catalyst – spillover and reverse spillover - Sensor

Module-3

Role of Surfaces in Bio-nano interactions

Adhesion and its importance – Adhesion vs cohesion – Work in adhesion and cohesion
- Theories on adhesion (Bradley, Hertz, JKR) - Methods of adhesion measurement (Scotch Tape, Peel test, Scratch, Blister, Ultrasonic and acoustic microcavitation methods) – Adhesion measurement in cell (observational, probing and counting techniques) - Surface modification and adhesion - Adhesion of nanoparticles, cells and between nanoparticle & cells - Cancer cell surface interaction.

Module-4

Tribological Aspects of Surfaces

Tribological aspects of adhesion, friction and wear – Friction and Friction Types – Theories of Macro (Amontons, Coulomb) and Nanoscale friction (Tomlinson, Frenkel- Kontorova, Bowden and Tabor models)– Difference between macro and micro/nano tribology- Wear – Wear Mechanisms and types – identification of different mechanisms – Wear theory (Archard, Rabinowictz, Bassani and D'Acunto Theory)– Characterization techniques for friction and wear – Tribometer, Friction Force Microscopy, Nanoindentation and Nanoscratching – Methods to reduce wear and Friction –Fracture –Lubrication –Surface Coatings

Module-5

Surfaces in Multidisciplinary Applications

Colloids– Optical and Electrical properties – Colloids in Drug Delivery – Electrical and Electronic properties of Surfaces –zeta potential - Corrosion – Coatings for corrosion protection –High temperature issues - New coating concepts in multilayer structures – thermal barrier coatings. Bioinspired materials – Tribology in

Human Body, Artificial organs and Medical devices –Nanosurfaces in Energy, Environmental, Automobile and Industrial Applications

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Gabor A. Somorjai, Yimin Li, Introduction to Surface Chemistry and Catalysis, Second Edition, John Wiley & Sons, New Jersey, 2010, ISBN: 978-0-470-50823-7.
2. HaraldIbach, Physics of Surfaces and Interfaces, Springer-Verlag, Berlin, 2006, ISBN: 978-3-540-34709-5.
3. Pankaj Vadgama, Surfaces and interfaces for biomaterials, First Edition, CRC Press, Boca Raton, 2005, ISBN: 0-8493-3446-6.
4. Peter J. Blau, Friction Scienceand Technology- From concepts to applications, Second Edition, CRC Press, Boca Raton, 2009, ISBN: 978-1-4200-5404-0.
5. I. Chorkendorff, J.W. Niemantsverdriet, Concepts of Modern Catalysis and Kinetics, First Edition, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2003, ISBN: 3-527-30574-2.
6. Didier Astruc, Nanopaticles and catalysis, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2008, ISBN: 978-3-527-31572-7.
7. N. Birks, G. H. Meier, F. S. Pettit, Introduction to the high temperature oxidation of metals, Second edition, Cambridge University Press, 2006, 978-0-521-48042-0.
8. Bharat Bhusan, Nanotribology and Nanomechanics, Springer, Berlin, 2005, ISBN: 978-3-540-24267-3.

Web links and Video Lectures (e-Resources):

- Surfaces and interfaces, importance: IIT Kanpur: https://www.youtube.com/watch?v=akEmtQTnyHo
- Surface characterization techniques, IIT Bombay: https://www.youtube.com/watch?v=7QhoFk1GczA
- Adsorption isotherms, IIT Kharagpur: https://www.youtube.com/watch?v=ueAUsgoUaxA
- Colloids and Surfaces, Prof. Basavaraj Madivala Gurappa, IIT Madras: https://nptel.ac.in/courses/105106204

Skill Development Activities Suggested

- Assignments
- Quizes
- Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Illustrate functional coatings (such as hydrophilic/ hydrophobic) and the measurement of physical properties	Apply
CO2	Execute surface characterization tools and interpretation of the outcome	Apply

Program Outcome of this course

Sl. No.	Description	POs
1	Engineering knowledge	1
2	Problem analysis	2
3	Design/development of solutions	3
4	Conduct investigations of complex problems	4
5	Modern tool usage	5

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x	x	x	x	x							
CO2	x	x	x	x	x							

Semester- II

LAB SAFETY AND HEALTH HAZARDS			
Course Code	**MINT216G**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives: To enable students to understand the following.

1. The requirement and importance of safety, first aid and ethics in the laboratory
2. Cleanroom lab requirement for the device fabrication at micro/nano scale
3. Identify and control hazards in cleanroom
4. Waste management of hazardous materials

Module-1

Cleanroom basics, hazards, and safety:

Basics of cleanroom design, classification standards, sources of particulate contamination, airflow, and filtration in the rooms. Cleanroom hazards: Fire, explosions, toxicity, and physical. Cleanroom operation, safety manual, and health issues: Operational procedures, personal protective equipment (PPE's), behavioural safety in cleanroom. Overview of ethics in science and technology. Social and ethical issues in research and plagiarism, Ethics in: research, clinical trials, and transplantation. Safe use of genetically modified organisms (GMO) and recombinant-DNA based products.

Module-2

Hazardous materials:

Category of hazardous materials: Flammable, reactive, corrosive, and toxic. Safe handling, storage, and disposal: Detail study of 'Safety Data Sheet' abbreviated to SDS. Specific material handling issues: DI water, solvents, cleaners, ion implantation sources, diffusion sources, photoresists, developers, metals, dielectrics, and toxic, flammable, corrosive, and high purity gases as well as packaging materials. Chemical hygiene plan, National and international shipping laws and labelling for hazardous materials.

Module-3

Biosafety and Toxicology:

Introduction biological safety, biohazards sources, and biosafety levels. Biological risk groups, assessment, analysis, and management. Government of India's biosafety guidelines. Overview of national and international agreements on biosafety: Cartagena Protocol. Toxicological overview of exposed particles, gases, and liquid chemicals. Systemic translocation of inhaled particles and gases. Toxicological assessment of nanoparticles, gases, and bio-agents: hazard identification, exposure assessment, and risk management. Indoor air quality: Indoor air quality measurements, assessment, and management

Module-4

Laboratory First-Aid and safety equipment:

Importance and principles of first aid in the laboratory. Training in first aid: General rules of first aid related to the acids, bases, and toxic gases. First aid against electric shock, Bleeding, inhalation problems, Burns, Hydrogen Fluoride exposure, and Eyes. Chemical spill control method. Dealing with emergencies.

Smoke sensor, smoke alarm, and sensors for toxic gases: installation and operation according to the state laws. Oxygen station, fire extinguishers, and fire suppression system: installation and operation according to the state laws. Chemical hoods and biosafety cabinets. Eyewash and shower station,

resuscitation units. Anti-electrostatic mats and clocks

Module-5

Waste management:

Types of laboratory waste: Chemical, biological, infectious, radioactive and mixed waste. What qualifies as hazardous waste: Flammable/ignitable; corrosive, reactive, toxic, persistent (Halogenated Organic Compounds and Polycyclic Aromatic Hydrocarbons), carcinogenic, trash rules and local sewer limits. Waste evaluation request, Hazardous waste accumulation rules and minimization, Infectious and biological waste, Waste handling and disposal training. Indian regulations for chemical and biological wastes

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books:

1. Cleanroom Technology: Fundamentals of Design, Testing, and Operation by William White, Print ISBN 0-471-86842-6, John Wiley & Sons Ltd, 2001
2. First Aid for Colleges and Universities by Keith J. Karren, 10th edition, ISBN 0321732596, Benjamin Cummings, 2011
3. Hazardous Waste Management by Michael D. LaGrega, Reissue edition, ISBN-13: 978-1577666936, Waveland Pr Inc, 2010

Reference Books:

Dekker Encyclopedia of Nanoscience and Nanotechnology, 3rd edition, Seven Volume Set, by Sergey Edward Lyshevski (Editor), ISBN-13: 9781439891346, CRC Press, 2014.

Web links and Video Lectures (e-Resources):

https://www.youtube.com/watch?v=mVMbex3WgQQ Safety training in cleanroom
https://www.youtube.com/watch?v=PfUohZu7l2k Biosafety Cabinet how it works / Laminar flow / Technical Animation /Clean room Equipment / BSC
https://www.youtube.com/watch?v=yuc6cNBrbxM

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Skill Development Activities Suggested

- Assignments
- Quizes
- Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	BloomsLevel
CO1	Explain cleanroom applications, lab safety, hazard, and ethics	Comprehension and evaluation
CO2	Evaluate controlling criteria for hazardous material in the cleanroom laboratory.	Evaluation

Program Outcome of this course

Sl. No.	Description	POs
1	Engineeringknowledge	1
2	Problemanalysis	2
3	Design/developmentofsolutions	3
4	Conductinvestigationsofcomplex problems	4
5	Moderntoolusage	5
6	The engineer and society	6
7	Environment and sustainability	7
8	Ethics:	8
9	Individual and team work:	9
10	Communication	10
11	Life long learning	12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x	x	x	x	x	x	x	x	x	x		x
CO2	x	x	x	x	x	x	x	x	x	x		x

DEVICE FABRICATION AND CHARACTERISATION LAB			
Course Code	**MNSTL207 / MINTL207**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	04	SEE Marks	50
Credits	2	Exam Hours	3

Course objectives:

- The learning objectives of the course are Knowledge to design and develop the nanostructured based devices
- Hands on experience to fabricate the devices based on nanomaterials
- Knowledge of device operation, data measurement, analysis of the device performance and their application.

Sl.NO	Experiments
1	Gas/Pressure Sensors device fabrication and device parameter measurement and analysis
2	Dye sensitized solar cell device fabrication, I-V measurement and Efficiency calculation
3	To preparation of electrodes for supercapacitor and calculate its specific capacitance using Cyclic voltammetry.
4	To fabricate metal oxide thin/thick film and analyse surface features using AFM
5	Fabrication of thin/thick films and its Crystal structure analysis using XRD
6	Design and Synthesis of 1D inorganic nanostructures and analyse their size and morphology by scanning electron micrograph
7	Preparation of 2D nanostructures and measure their thickness and morphology by AFM.
8	Modification of electrodes by nanomaterial for voltammetric applications
9	Fabrication of electrode for electrochemical oxidation of organic molecules.
10	Battery device Fabrication and its performance data analysis.
11	
12	

Course outcomes (Course Skill Set):

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

1. Design the nanomaterial for suitable application
2. Basic hands on experience to fabricate selected nanomaterials based devices
3. Knowledge to operate the device and measure data.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- **Total marks scored by the students are scaled down to 30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 01 tests for 100 marks, test shall be conducted after the 14th week of the semester.
- In test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- **The test marks is scaled down to 20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and marks of test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100

marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Suggested Learning Resources:

1. Characterization of Nanostructure materials by XZ.L.Wang
2. Instrumental Methods of Analysis, 7th edition- Willard, Merritt, Dean, Settle
3. *Scanning Probe Microscopy: Analytical Methods (NanoScience and Technology)-Roland Wiesendanger*

References:

4. X-Ray Diffraction Procedures: For Polycrystalline and Amorphous Materials, 2nd Edition Harold P. Klug, Leroy E. Alexander
5. Transmission Electron Microscopy: A Textbook for Materials Science (4-Vol Set)- David B. Williams and C. Barry Carter
6. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM - Ray F. Egerton..

TECHNICAL WRITING AND PRESENTATION			
Course Code	**MNST257A / MINT257A**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	0:0:2	SEE Marks	50
Total Hours of Pedagogy	20	Total Marks	100
Credits	1	Exam Hours	3

The objective of the course is to develop essential skills of academic writing, writing research papers and making presentations.

Module-1

Differences between Academic and Technical Writing.
Technical Writing-Basic Principles : Words-Phrases-Sentences, Construction of Cohesive Paragraphs, Elements of Style
Principles of Summarizing : Abstract , Summary, Synopsis

Module-2

Technical Writing for Engineers, Technical writing ethics,
Technical Reports: Salient Features, Types of Reports, Structure of Reports, Data Collection, Use of Graphic Aids, Drafting and Writing. Technical Writing and Management Skills

Module-3

Writing Research Papers: Basic Guidelines, Documentation. Ethical Considerations in Technical Writing.

Module-4

Technical Presentation: Informal, formal. Preparing a Presentation.
Speaking Skills, Accuracy vs. Fluency, The Audience, Pronunciation Guidelines, Voice Control

Module-5

Professional Presentations: Planning, Preparing , Presentation Strategies, Overcoming Communication Barriers, Using Technology, Effective Presentations

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

1. Kumar, Sanjay & Pushp Lata, "Communication Skills", Oxford University Press,2011
2. Quirk & Randolph, " A University Grammar of English", Pearson,2006
3. Rutherford, Andrea J., " Basic Communication Skills for Technology", Pearson, 2007
4. Rizvi, M Ashraf, "Effective Technical Communication", McGraw Hill,2009
5. Leigh, Andrew & Maynard, Michael, "The Perfect Presentation", Random House
6. Barker, Larry L., "Communication", Prentice-Hall
7. Lesikar & Flatley, "Basic Business Communication-Skills For Empowering the Internet Generation", Tata McGraw-Hill

Web links and Video Lectures (e-Resources):

Skill Development Activities Suggested

- Assignments
- Quizes
- Seminars

Course outcome (Course Skill Set)

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

1. Develop an understanding of the rules of academic writing
2. Differentiate between abstracts, summaries and synopses –
3. Write technical reports
4. Be familiar with research skills and documenting sources –
5. Make effective presentations

Program Outcome of this course

Sl. No.	Description	POs
1	Engineeringknowledge	1
2	Problemanalysis	2
3	Design/developmentofsolutions	3
4	Conductinvestigationsofcomplex problems	4
5	Moderntoolusage	5
6	The engineer and society	6
7	Environment and sustainability	7
8	Ethics:	8
9	Individual and teamwork:	9
10	Communication	10
11	Lifelong learning	12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x	x	x	x	x	x	x	x	x	x		x
CO2	x	x	x	x	x	x	x	x	x	x		x
CO3	x	x	x	x	x	x	x	x	x	x		x
CO4	x	x	x	x	x	x	x	x	x	x		x
CO5	x	x	x	x	x	x	x	x	x	x		x

PROBLEM SOLVING TECHNIQUES IN SCIENCE AND ENGINEERING			
Course Code	**MNST257B / MINT257B**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	1:0:0	SEE Marks	50
Total Hours of Pedagogy	10	Total Marks	100
Credits	1	Exam Hours	3

Introduction to Decision Making and Structured Problem Solving: Introduction to structured problem-solving techniques in technology and engineering business processes; analysis tools; analysis skill set; process of analysis; the three sights and data; decision making and problem solving

Module-1

Failure Analysis: Failure analysis methods of FRACAS, FMEA, FMECA, fault tree analysis (FTA) and event tree analysis (ETA); forensic engineering; materials, processes, and personnel; case studies Elicitations and Analysis of Requirements: The nine techniques of root cause analysis; the ten stakeholders; critical success factors; elicitation process

Module-2

Analysis Tools for Problem Identification: Cause and effect (fishbone or Ishikawa) diagrams; check sheets; process control charts

Prioritizing and Decision-Making Tools: Pareto analysis; value analysis; SWOT analysis; PEST analysis; cost-benefit analysis

Module-3

Process Identification, Planning, and Improving Tools: Flow charts; SIPOC diagrams; project network diagrams; PERT and CPM; capacity planning; SREDIM; Radar charts

Module-4

Advanced Problem Solving Techniques: Ford Motor Company's technique of eight disciplines (8Ds), John Boyd's observe-orient-decide-act (OODA) loop, Deming's plan-do-check-act (PDCA) and Toyota's A3 approaches for quality control, RCASE, regression analysis, TRIZICS, Six Sigma through DMAIC and DMADV; innovation roadmap; subversion analysis

Module-5

Review of Structured Problem-Solving Techniques: Countermeasures and standardizing processes to eliminate problems: Design innovations; performance measurement – key performance indicators in project management (time, quality with reliability, cost); benchmark; developing engineering standards; improvement priorities – customers, competitors, organization

Assessment Details (both CIE and SEE)

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3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Book:

1. **An Introduction to Business Systems Analysis: Problem Solving Techniques and Strategies, 1st Edition, by Eugene O'Loughlin, ISBN-10: 1905785615; ISBN-13: 978- 905785612; The Liffey Press, 2009.**

Reference Books:

1. **The Engineer at Large: The Essential Guide to Structured Problem Solving and Creative Innovation, by Gordon Cameron, ISBN-10: 150331832X; ISBN-13: 978-1503318328; TRIZ, 2015.**

Web links and Video Lectures (e-Resources):

1. Mind Tools: Problem-Solving Techniques: http://www.mindtools.com/pages/main/newMN_TMC.htm#general
2. YouTube: https://www.youtube.com/watch?v=4iFFbHeOZvo
3. https://www.youtube.com/watch?v=IQ_wDfnKoQU
4. https://www.youtube.com/watch?v=Kz5Pr8aPKtw
5. Eugene O'Loughlin's 22 video lessons on Problem-Solving Techniques: https://www.youtube.com/playlist?list=PL9F789252CC28FB3A

ALD Reliability Software

1. http://aldservice.com/en/Download/download-reliability-and-safety-software.html

Skill Development Activities Suggested

- Assignments
- Quizes
- Seminars

Course outcome (Course Skill Set) At the end of the course the student will be able to :	
1. Explain the importance of organizational decision-making and structured problem solving in engineering and nanotechnology professions	**Understanding**
2. Analyze failures of technology projects in technical and business organizations	**Analysis**
3. Formulate varieties of elicitation methods in problem solving	**Analysis**
4. Use analysis, prioritizing, and decision-making tools in structured problem solving	**Analysis**
5. Illustrate process identification, planning, and improving tools such as flow chart, PERT, radar charts, etc.	**Analysis**
6. Employ advanced problem solving and process improvement techniques such as 8Ds, OODA, A3, RCASE, regression analysis, TRIZICS, and Six Sigma	**Analysis**

Program Outcome of this course

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3	Design/developmentofsolutions	3
4	Conductinvestigationsofcomplex problems	4
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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	x	x	x	x	x	x	x	x	x	x		x
CO2	x	x	x	x	x	x	x	x	x	x		x