Continuous Internal Evaluation (CIE):

For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks."

Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1)

Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1.

The remaining 15 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for the practical test as indicated in the Table 1.

The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2

Course Outcomes

1. Fabricate thin films using suitable deposition techniques for engineering applications.
2. Characterize structural, optical, electrical, and surface properties of thin films.
3. Analyze the influence of deposition and processing parameters on thin-film performance.
4. Design and conduct open-ended investigations involving thin-film devices and applications.
5. Interpret characterization results and communicate technical findings effectively.

CO-PO Mapping

COs	PO1	PO2	PO3
CO1	3	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	3	3
CO5	2	3	3

II Semester

Advanced 2D Nanomaterials			
Course Code	**1MNST201**	Scheme	2026
Type of Course	PCC	Semester	2
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:28:50	SEE Marks	50
Credits	04	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Objectives

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

1. Understand the fundamental properties, synthesis methods, and characterization techniques of advanced two-dimensional (2D) nanomaterials.
2. Analyze the structure–property relationships governing the electrical, optical, mechanical, and thermal behavior of 2D materials.
3. Investigate emerging 2D materials beyond graphene and their potential applications.
4. Evaluate fabrication, heterostructure engineering, and functionalization strategies for advanced device applications.
5. Develop research-oriented approaches for utilizing 2D nanomaterials in electronics, energy, sensing, and biomedical technologies.

Module-1

Fundamentals of 2D Nanomaterials

Introduction to two-dimensional materials; history and evolution of graphene research; classification of 2D nanomaterials; crystal structures and bonding; electronic band structures; quantum confinement effects; mechanical, thermal, optical, and electrical properties; characterization techniques for 2D materials.

Number of Hours:09

Module-2

Synthesis and Processing of 2D Nanomaterials

Mechanical exfoliation; liquid-phase exfoliation; chemical vapor deposition (CVD); molecular beam epitaxy; atomic layer deposition; bottom-up and top-down approaches; transfer techniques; large-area synthesis; defect engineering; scalability and industrial manufacturing challenges.

Number of Hours:09

Module-3

Emerging 2D Materials Beyond Graphene

Transition metal dichalcogenides (MoS_2, WS_2, WSe_2); hexagonal boron nitride (h-BN); phosphorene; silicene and germanene; MXenes; layered double hydroxides; 2D oxides and nitrides; electronic and optoelectronic properties; comparative analysis of emerging 2D materials.

Number of Hours:08

Module-4

Functionalization and Heterostructure Engineering

Surface chemistry of 2D materials; covalent and non-covalent functionalization; van der Waals heterostructures; strain engineering; defect engineering; interface phenomena; quantum transport; tunable properties through heterostructure design; flexible and wearable devices.

Number of Hours:08

Module-5

Applications of Advanced 2D Nanomaterials

2D materials for nanoelectronics and optoelectronics; field-effect transistors; photodetectors; flexible electronics; energy storage and conversion devices; supercapacitors and batteries; hydrogen evolution reaction; biosensors and healthcare applications; environmental remediation; future prospects and challenges.

Number of Hours:08

Textbooks:

1. Phaedon Avouris, Tony Heinz and Tony Low, 2D Materials: Properties and Devices, Cambridge University Press.
2. Manijeh Razeghi, Fundamentals and Applications of Graphene and 2D Materials, Woodhead Publishing.
3. Jamie H. Warner, Franziska Schäffel, Mark Rummeli and Ali Bachmatiuk, Graphene: Fundamentals and Emergent Applications, Elsevier.

Reference books / Manuals:

1. Challa S.S.R. Kumar, Graphene-Based Nanomaterials: Synthesis, Properties and Applications, Wiley.
2. Francesca Iacopi, John J. Boeckl and Chennupati Jagadish, 2D Materials for Nanoelectronics, Elsevier.
3. Paolo Bondavalli, 2D Materials for Electronics, Sensors and Devices, Elsevier.
4. Bharat Bhushan, Springer Handbook of Nanotechnology, Springer.

Web links and Video Lectures (e-Resources):

1. PhysicalMethods:Dr.R.Nagarajan,DepartmentofChemicalEngineering,IITMadras:https://www.youtube.com/watch?v=WK9i1F4fOik
2. https://ocw.mit.edu?utm_source=chatgpt.com
3. https://nanohub.org?utm_source=chatgpt.com

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Course Outcomes

1. Explain the structural, electronic, optical, and mechanical properties of advanced 2D nanomaterials.
2. Analyze various synthesis, processing, and characterization techniques used for the fabrication of 2D materials.
3. Evaluate the performance of emerging 2D materials and heterostructures for advanced technological applications.
4. Apply functionalization and interface engineering strategies to tailor the properties of 2D nanomaterials.
5. Develop innovative solutions utilizing 2D nanomaterials for nanoelectronics, energy storage, sensing, biomedical, and environmental applications.

Mappingof COSandPOs

COs / POs	PO1	PO2	PO3
CO1	1	1	3
CO2	2	1	3
CO3	3	1	3
CO4	3	2	3
CO5	3	3	2

Semiconductor materials and Fabrication Technology			
Course Code	**1MNST202**	Scheme	2026
Type of Course	PCC	Semester	2
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:0:48	SEE Marks	50
Credits	03	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Objectives

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

1. To provide practical exposure to semiconductor materials and device fabrication processes.
2. To understand the preparation, characterization, and processing of semiconductor materials.
3. To study the influence of fabrication parameters on semiconductor device performance.
4. To develop skills in semiconductor characterization and process optimization.
5. To enable students to apply fabrication technologies for electronic and nanoelectronics devices.

Module-1

Fundamentals of Semiconductor Materials

Introduction to semiconductors; intrinsic and extrinsic semiconductors; energy band theory; charge carriers and carrier transport; direct and indirect bandgap materials; elemental and compound semiconductors; semiconductor crystal structures; defects and impurities; electrical, optical, and thermal properties of semiconductor materials; semiconductor characterization techniques.

Number of Hours:09

Module-2

Semiconductor Crystal Growth and Wafer Technology

Crystal growth techniques; Czochralski and Float Zone methods; epitaxial growth; wafer fabrication and processing; wafer cleaning and surface preparation; oxidation of silicon; diffusion and ion implantation; semiconductor doping techniques; process integration and yield considerations.

Number of Hours:09

Module-3

Thin Film Deposition and Patterning Technologies

Physical vapor deposition (PVD); chemical vapor deposition (CVD); atomic layer deposition (ALD); sputtering and evaporation techniques; thin-film growth mechanisms; etching techniques; dry and wet etching; process characterization; thin-film materials for semiconductor devices; emerging deposition technologies.

Number of Hours:08

Module-4

Semiconductor Device Fabrication and Characterization

Fabrication of p-n junctions; Schottky and Ohmic contacts; MOS capacitor fabrication; CMOS process flow; device isolation techniques; metallization and interconnects; electrical characterization of semiconductor devices; I-V and C-V measurements; reliability and failure analysis.

Number of Hours:08

Module-5

Advanced Semiconductor Technologies and Applications

Wide bandgap semiconductors (SiC, GaN); compound semiconductors; semiconductor nanomaterials; MEMS and NEMS fabrication; flexible and wearable electronics; semiconductor devices for sensors and optoelectronics; advanced packaging technologies; future trends in semiconductor manufacturing and nanoelectronics.

Number of Hours:08

Textbooks:

1. S. M. Sze and Kwok K. Ng, Physics of Semiconductor Devices, 3rd Edition, Wiley.
2. Stephen A. Campbell, Fabrication Engineering at the Micro and Nanoscale, Oxford University Press.
3. Sorab K. Ghandhi, VLSI Fabrication Principles: Silicon and Gallium Arsenide, Wiley.

Reference books / Manuals:

1. Robert F. Pierret, Semiconductor Device Fundamentals, Pearson Education.
2. Jaeger Richard C., Introduction to Microelectronic Fabrication, Pearson.
3. Marc J. Madou, Fundamentals of Microfabrication and Nanotechnology, CRC Press.
4. Plummer, Deal and Griffin, Silicon VLSI Technology: Fundamentals, Practice and Modeling, Pearson.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/117106033

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Course Outcomes

1. Explain the fundamental properties and behavior of semiconductor materials and charge transport mechanisms.
2. Analyze crystal growth, doping, oxidation, and wafer processing techniques used in semiconductor manufacturing.
3. Evaluate thin-film deposition, etching, and patterning processes for semiconductor device fabrication.

4. Apply semiconductor fabrication and characterization techniques for the development of electronic devices.
5. Assess emerging semiconductor technologies and their applications in nanoelectronics, sensors, and advanced integrated systems.

Mappingof COSandPOs

COs / POs	PO1	PO2	PO3
CO1	1	1	3
CO2	2	1	3
CO3	3	1	3
CO4	3	2	3
CO5	3	3	2

Quantum Materials			
Course Code	**1MNST203**	Scheme	2026
Type of Course	PCC	Semester	2
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:0:48	SEE Marks	50
Credits	03	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Objectives

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

1. Provide a comprehensive understanding of the fundamental principles governing quantum materials and quantum phenomena in condensed matter systems.
2. Develop knowledge of electronic, magnetic, superconducting, and topological properties of advanced quantum materials.
3. Introduce the synthesis, characterization, and theoretical concepts associated with low-dimensional and strongly correlated quantum systems.
4. Explore emerging quantum materials for applications in quantum computing, spintronics, sensing, communication, and next-generation electronic devices.
5. Enable students to analyze and evaluate the role of quantum materials in addressing challenges in modern technology and future quantum-enabled systems.

Module-1

Fundamentals of Quantum Materials

Introduction to quantum materials; quantum mechanics review for condensed matter systems; electronic band structure; quantum confinement effects; wave-particle duality; density of states; Fermi energy and Fermi surface; electron correlation; low-dimensional systems; quantum phase transitions; characterization techniques for quantum materials.

Number of Hours:09

Module-2

Topological and Low-Dimensional Quantum Materials

Topological insulators; topological semimetals; Dirac and Weyl materials; quantum Hall effect; quantum spin Hall effect; graphene and other two-dimensional quantum materials; edge states and surface states; quantum transport phenomena; applications in next-generation electronics.

Number of Hours:09

Module-3

Superconducting and Magnetic Quantum Materials

Fundamentals of superconductivity; BCS theory; high-temperature superconductors; Josephson effect; Cooper pairs; quantum magnetic materials; spin liquids; spintronics; quantum magnetism; strongly correlated electron systems; characterization of superconducting and magnetic materials.

Number of Hours:08

Module-4

Quantum Phenomena and Advanced Characterization

Quantum tunneling; quantum coherence and entanglement; quantum oscillations; excitons and polaritons; spectroscopic characterization techniques; scanning tunneling microscopy (STM); angle-resolved photoemission spectroscopy (ARPES); neutron scattering; synchrotron-based characterization; quantum sensing techniques.

Number of Hours:08

Module-5

Applications of Quantum Materials

Quantum computing materials; superconducting qubits; spin qubits; quantum communication systems; quantum sensors; quantum materials for energy-efficient electronics; neuromorphic computing; quantum photonic devices; challenges in scalable quantum technologies; future prospects and emerging research directions.

Number of Hours:08

Textbooks:

1. E. Y. Andrei and M. S. Dresselhaus, Physics and Applications of Graphene and Quantum Materials, Springer.
2. Edward McCann and Mikito Koshino, Graphene and Quantum Materials, Oxford University Press.
3. Supriyo Datta, Quantum Transport: Atom to Transistor, Cambridge University Press.

Reference books / Manuals:

1. Michael Z. Hasan and Charles L. Kane, Topological Insulators and Topological Superconductors, Reviews of Modern Physics.
2. B. D. Cullity and C. D. Graham, Introduction to Magnetic Materials, Wiley.
3. Steven M. Girvin and Kun Yang, Modern Condensed Matter Physics, Cambridge University Press.
4. Bharat Bhushan, Springer Handbook of Nanotechnology, Springer.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/115106101
2. https://nptel.ac.in/courses/115106122
3. https://ocw.mit.edu/courses/8-04-quantum-physics-i-spring-2016/

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Course Outcomes

1. Explain the fundamental concepts governing the behavior of quantum materials and low-dimensional systems.
2. Analyze the electronic, magnetic, and topological properties of advanced quantum materials.
3. Evaluate superconducting, spintronic, and strongly correlated quantum materials for technological applications.
4. Apply advanced characterization techniques to investigate quantum phenomena in materials.
5. Assess the potential of quantum materials for quantum computing, sensing, communication, and next-generation electronic devices.

Mappingof COSandPOs

COs / POs	PO1	PO2	PO3
CO1	1	1	3
CO2	2	1	3
CO3	3	1	3
CO4	3	2	3
CO5	3	3	2

Design and Fabrication of Nano materials and Devices			
Course Code	**1MNST204**	Scheme	2026
Type of Course	PCC	Semester	2
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:0:48	SEE Marks	50
Credits	03	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Objectives

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

1. Understand the operating principles, design methodologies, and fabrication approaches of advanced nanoelectronic devices and nanosystems.
2. Develop knowledge of quantum materials, low-dimensional systems, and their role in next-generation nanodevices.
3. Explore nanofabrication processes, device integration strategies, and characterization techniques used in nanoscale technologies.
4. Analyze the performance, reliability, and functional properties of nanodevices through advanced characterization methods.
5. Investigate nanosensors, nanoelectromechanical systems, and emerging nanodevice applications in electronics, healthcare, energy, and environmental technologies.

Module-1

Nanoelectronic Devices

Introduction to nanoelectronics; device scaling and Moore's law limitations; quantum confinement in nanodevices; single-electron transistors (SETs); resonant tunneling diodes (RTDs); carbon nanotube field-effect transistors (CNTFETs); graphene-based transistors; nanowire transistors; quantum dot devices; charge transport mechanisms; performance metrics and reliability issues in nanoelectronic devices.

Number of Hours:09

Module-2

Topological and Low-Dimensional Quantum Materials

Topological insulators; topological semimetals; Dirac and Weyl materials; quantum Hall effect; quantum spin Hall effect; graphene and other two-dimensional quantum materials; edge states and surface states; quantum transport phenomena; applications in next-generation electronics.

Number of Hours:09

Module-3

Nanofabrication and Device Integration

Thin-film fabrication; nanopatterning techniques; nanowires and nanotubes fabrication; nanoelectronic device fabrication; MEMS and NEMS concepts; nanocomposites and hybrid nanostructures; device packaging and integration; reliability and performance evaluation of nanodevices.

Number of Hours:08

Module-4

Characterization and Performance Evaluation

Structural characterization using XRD, SEM, TEM and AFM; optical characterization using UV-Visible and photoluminescence spectroscopy; electrical characterization techniques; surface analysis methods; electrochemical characterization; device performance metrics; failure analysis and quality control.

Number of Hours:08

Module-5

Nanosensors and Functional Nanodevices

Fundamentals of nanosensors; physical, chemical, and biological sensing mechanisms; nanomaterial-based gas sensors; biosensors and lab-on-chip devices; MEMS and NEMS devices; nanoelectromechanical systems for sensing and actuation; flexible and wearable nanodevices; plasmonic and photonic nanodevices; energy harvesting nanodevices; device integration and real-world applications.

Number of Hours:08

Textbooks:

1. Supriyo Datta, Quantum Transport: Atom to Transistor, Cambridge University Press.
2. Bharat Bhushan, Springer Handbook of Nanotechnology, Springer.
3. Marc J. Madou, Fundamentals of Microfabrication and Nanotechnology, CRC Press.

Reference books / Manuals:

1. Vladimir V. Mitin, Viatcheslav A. Kochelap and Michael A. Stroscio, Quantum Heterostructures: Microelectronics and Optoelectronics, Cambridge University Press.
2. Hari Singh Nalwa, Handbook of Nanostructured Materials and Nanotechnology, Academic Press.
3. Challa S.S.R. Kumar, Nanomaterials for Medical Diagnosis and Therapy, Wiley-VCH.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/@nptelhrd
2. https://www.youtube.com/@nanoHUB
3. https://ocw.mit.edu

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Course Outcomes

1. Explain the operating principles and performance characteristics of advanced nanoelectronic devices and low-dimensional quantum materials.
2. Analyze quantum transport phenomena and the role of emerging quantum materials in nanoscale electronic systems.
3. Evaluate nanofabrication processes and device integration techniques used in the realization of nanodevices.
4. Apply advanced characterization techniques to assess the structural, optical, electrical, and functional properties of nanomaterials and devices.
5. Design and develop nanosensors and functional nanodevices for applications in electronics, healthcare, energy, and environmental monitoring.

Mappingof COSandPOs

COs / POs	PO1	PO2	PO3
CO1	1	1	3
CO2	2	1	3
CO3	3	1	3
CO4	3	2	3
CO5	3	3	2

MEMS & NEMS for Nanotechnology			
Course Code	**1MNST205A**	Scheme	2026
Type of Course	PEC-III	Semester	2
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:0:48	SEE Marks	50
Credits	03	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Objectives

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

1. Understand the fundamentals, historical evolution, scaling laws, and multidisciplinary nature of MEMS technology.
2. Analyze the working principles of MEMS sensors, actuators, and smart microsystems used in industrial, biomedical, and consumer applications.
3. Acquire knowledge of MEMS materials, microfabrication processes, silicon micromachining, and wafer-level manufacturing techniques.
4. Examine electro-mechanical interactions, signal conditioning circuits, RF MEMS devices, and modeling tools used in MEMS design.
5. Understand integration, packaging, testing, reliability, and qualification methodologies for MEMS-based microsystems.

Module-1

Introduction to MEMS

Historical background of Micro Electro Mechanical Systems, Feynman' s vision, Nano Technology and its Applications Multi-disciplinary aspects, Basic Technologies, Applications areas, Scaling Laws in miniaturization, scaling in geometry, electrostatics, electromagnetic, electricity and heat transfer.

Number of Hours:09

Module-2

Micro and Smart Devices and Systems

Principles Transduction Principles in MEMS Sensors: Micro sensors-thermal radiation, mechanical and bio-sensors, Actuators: Different actuationmechanisms -silicon capacitiveaccelerometer, piezo-resistive pressure sensor, blood analyzer, conductometric gas sensor, silicon micro-mirror arrays, piezo-electric based inkjet print head, electrostatic comb-driver, Smart phone application, Smart buildings

Number of Hours:09

Module-3

Materials and Micro manufacturing

Semiconducting Materials., Silicon, Silicon dioxide, Silicon Nitride, Quartz, Poly Silicon, Polymers, Materials for wafer processing, Packaging Materials Silicon wafer processing, lithography, thin-film deposition, etching (wet and dry), wafer-bonding. Silicon micromachining: surface, bulk, LIGA process, Wafer bonding process.

Number of Hours:08

Module-4

Electrical and Electronics aspects

Electrostatics, Coupled Electro mechanics, stability and Pull-in phenomenon, Practical signal conditioning Circuits for Microsystems. Characterization of pressure sensors, RF MEMS.
Switches varactors, tuned filters. Micromirror array for control and switching in optical

communication, Application circuitsbased on microcontrollers for pressure sensor, Accelerometer,Modeling using CAD Tools (Intellisuite)

Number of Hours:08

Module-5

Integration and Packaging of Microelectromechanical Systems

Integration of microelectronics and micro devices at wafer and chip levels. Microelectronic packaging: wire and ball bonding, flip-chip. Microsystem packaging examples, Testing of Micro sensors, Qualification of Mems devices

Number of Hours:08

Textbooks:

1. G. K. Ananthasuresh, K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat, V. K. Aatre, ―Micro and Smart Systems‖, Wiley India, 2010.
2. T R Hsu, ―MEMS and Microsystems Design and Manufacturing‖, Tata McGraw Hill, 2nd Edition, 2008

Reference books / Manuals:

1. Chang Liu, ―Foundations of MEMS‖, Pearson International Edition, 2006.
2. S. D. Senturia, ―Micro System Design‖, Springer International Edition, 2001.

Web links and Video Lectures (e-Resources):

1. https://www.memsnet.org?utm_source
2. https://ocw.mit.edu?utm_source

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Course Outcomes

1. Explain the evolution, principles, scaling laws, and application domains of MEMS and microsystems.
2. Analyze the operation and performance of MEMS-based sensors, actuators, and smart devices for diverse engineering applications.
3. Evaluate suitable materials, microfabrication processes, lithography, etching, micromachining, and wafer bonding techniques for MEMS manufacturing.

4. Apply electrostatic and electromechanical principles in the design and analysis of MEMS devices, RF MEMS components, and signal conditioning circuits using CAD tools.
5. Assess integration, packaging, testing, reliability, and qualification techniques for MEMS devices and microsystems.

Mappingof COSandPOs

Course Outcomes	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	2	3	3

Thin Film Technology & Surface Engineering			
Course Code	**1MNST205B**	Scheme	2026
Type of Course	PEC-III	Semester	2
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:0:48	SEE Marks	50
Credits	03	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Objectives

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

1. To understand the fundamentals of tribology, wear mechanisms, corrosion, and surface degradation in engineering materials.
2. To study conventional surface engineering methods and their role in enhancing surface properties and performance.
3. To analyze advanced surface modification techniques based on energy beams and plasma-assisted processes.
4. To understand advanced coating technologies and deposition techniques used for nanostructured coatings.
5. To explore functional coatings and their applications in energy, electronics, biomedical, optical, and sensing devices.

Module-1

Fundamentals

Introduction to tribology, surface degradation, wear and corrosion, types of wear, adhesive, abrasive, oxidative, corrosive, erosive and fretting wear, classification of nano coatings, definition, scope and general principles, application of surface engineering towards nanomaterials.

Number of Hours:09

Module-2

Conventional surface engineering: Surface engineering by material removal, material addition, surface modification using liquid/molten bath, thermal and chemical treatments, gaseousmedium etc.

Number of Hours:09

Module-3

Advanced surface engineering practices: Surface engineering by energy beams, laser assisted microstructural and compositional modification, electron and laser beam, ion beam,plasma beam

Number of Hours:08

Module-4

Advanced coating practices : Cold spray, sputter deposition, ionimplantation, sol-gel technique, electrolysis and electroless techniques, HVOF, PVD, PECVD, CVD, ALD etc.

Number of Hours:08

Module-5

Functional coatings and Applications: Brush, Screen printing, Spray, powder, Dip-coating, ED, Fluidized Bed, Electrostatic spray gun, photovoltaics, bio-and chemical sensors, semiconductors, polymers and composites, electronic, opticaland magnetic devices, modelling

Number of Hours:08

Textbooks:

1. Morton, P.H., —Surface Engineering & Heat Treatment||, I.I.T, Brooke field. 1991
2. —ASM Metals Handbook: Surface Cleaning, Finishing & Coating||, Tenth Edition, Vol.5, Ohio, Metals Park, USA. 2000
3. Satas, D. and Tracton, A.A., —Coating technology handbook||, Mercel Dekker, New York. 2001

Reference books / Manuals:

1. Davis, J.R., (Ed.)., —Surface Engineering for Corrosion and Wear Resistance||, ASM International, Materials Park, Ohio. 2001
2. Fontana, M.G., —Corrosion Engineering||, 3rd Edition, M. C. Graw Hill, New York. 2005
3. Winston Revie, R., (Ed.), —Uhlig's Corrosion Handbook||, 3rd Edition, John Wiley & Sons. New York. USA. 2011

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/@nptelhrd?utm_source=chatgpt.com
2. https://www.youtube.com/@mitocw?utm_source=chatgpt.com
3. https://www.springernature.com?utm_source=chatgpt.com

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Course Outcomes

1. Explain tribological principles, wear mechanisms, corrosion processes, and the significance of nanocoatings in surface engineering.
2. Evaluate conventional surface engineering techniques including thermal, chemical, and material addition/removal processes for improving surface performance.
3. Analyze advanced surface modification methods employing laser, electron, ion, and plasma beam technologies.
4. Assess various advanced coating techniques such as PVD, CVD, PECVD, ALD, sputtering, ion implantation, HVOF, and cold spray for specific applications.
5. Design and evaluate functional coating systems for applications in photovoltaics, sensors, electronics, polymers, composites, optical, and magnetic devices.

Mappingof COSandPOs

COs \ POs	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

Perovskite Materials & Devices			
Course Code	**1MNST205C**	Scheme	2026
Type of Course	PEC-III	Semester	2
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:0:48	SEE Marks	50
Credits	03	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Objectives

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

1. To introduce the crystal structure, chemistry, and fundamental properties of perovskite materials.
2. To understand synthesis, fabrication, and characterization techniques used for perovskite materials and thin films.
3. To analyze the optical, electrical, and electronic properties of perovskites for device applications.
4. To study the design, operation, and performance of perovskite-based photovoltaic, optoelectronic, and sensing devices.
5. To evaluate stability, degradation mechanisms, and emerging trends in perovskite materials and device technologies.

Module-1

Fundamentals of Perovskite Materials

Introduction to perovskite materials; historical development and evolution of perovskite research; crystal structure and crystallography of ABX_3 perovskites; Goldschmidt tolerance factor; organic, inorganic and hybrid perovskites; halide perovskites; phase stability and polymorphism; structural, optical, electronic and dielectric properties; band structure engineering; defects and defect chemistry in perovskite materials.

Number of Hours:09

Module-2

Synthesis and Characterization of Perovskite Materials

Synthesis techniques for perovskite materials; solution processing methods; spin coating; dip coating; doctor blade coating; vapor-assisted deposition; thermal evaporation; chemical vapor deposition; thin-film growth mechanisms; morphology control; crystallization dynamics; structural characterization using XRD; morphological analysis using SEM, TEM and AFM; optical characterization using UV-Visible spectroscopy, photoluminescence and Raman spectroscopy; electrical and surface characterization techniques.

Number of Hours:09

Module-3

Electronic and Optoelectronic Properties

Charge carrier generation and transport mechanisms; exciton formation and dissociation; charge recombination processes; carrier diffusion length and mobility; interface engineering; energy band alignment; defect passivation techniques; optical absorption and emission characteristics; photophysical processes in perovskites; theoretical modeling and simulation of perovskite materials and devices.

Number of Hours:08

Module-4

Perovskite-Based Devices

Perovskite solar cells: device architectures, operational principles and performance parameters; mesoporous, planar and tandem solar cells; efficiency enhancement strategies; perovskite light-emitting diodes (PeLEDs); photodetectors; lasers; field-effect transistors; memristors and neuromorphic devices; perovskite-based gas, chemical and biosensors; flexible and wearable perovskite electronics.

Number of Hours:08

Module-5

Stability, Reliability and Emerging Applications

Degradation mechanisms in perovskite materials and devices; effects of moisture, oxygen, heat and light exposure; encapsulation techniques; reliability assessment and lifetime prediction; lead toxicity and environmental concerns; lead-free perovskite materials; scalable manufacturing and commercialization challenges; perovskites for energy storage; photocatalysis; photonics; quantum devices; emerging trends and future prospects of perovskite technologies.

Number of Hours:08

Textbooks:

1. Perovskite Photovoltaics: Basic to Advanced Concepts and Implementation, Academic Press, 2018.
2. Halide Perovskites: Photovoltaics, Light Emitting Devices and Beyond, Wiley, 2023.
3. Perovskite Materials: Synthesis, Characterisation, Properties and Applications, IntechOpen.

Reference books / Manuals:

1. Perovskite Materials – Synthesis, Characterisation, Properties and Applications.
2. Metal Halide Perovskite Semiconductors, Wiley.
3. Perovskite Solar Cells: Principle, Materials and Devices, Elsevier.
4. Advanced Functional Materials Based on Perovskites, Springer.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/@nptelhrd?utm_source=chatgpt.com
2. https://www.youtube.com/@mitocw?utm_source=chatgpt.com
3. https://www.nrel.gov?utm_source=chatgpt.com

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Course Outcomes

1. Explain the structure, composition, classification, and fundamental properties of perovskite materials.
2. Analyze synthesis methods, thin-film fabrication processes, and characterization techniques for perovskite materials
3. Evaluate the optical, electrical, and charge transport properties of perovskite materials for electronic and optoelectronic applications.
4. Design and assess the performance of perovskite-based solar cells, LEDs, photodetectors, and sensor devices.
5. Investigate stability challenges, degradation mechanisms, and advanced approaches for high-performance and durable perovskite devices.

Mappingof COSandPOs

COs \ POs	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

Advanced Polymer Nanocomposites			
Course Code	**1MNST205D**	Scheme	2026
Type of Course	PEC-III	Semester	2
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:0:48	SEE Marks	50
Credits	03	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Objectives

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

1. To understand the fundamentals, structure, and processing of polymer nanocomposites.
2. To study various nanofillers, fabrication methods, and interfacial engineering techniques.
3. To analyze the structural, thermal, mechanical, electrical, and functional properties of polymer nanocomposites.
4. To explore advanced multifunctional polymer nanocomposites for engineering and biomedical applications.
5. To evaluate emerging applications, sustainability aspects, and future developments in polymer nanocomposite technologies.

Module-1

Fundamentals of Polymer Nanocomposites

Introduction to polymers and nanocomposites; classification of polymers and nanomaterials; fundamentals of polymer nanocomposites; historical development and current trends; matrix–filler interactions; nanofillers and their characteristics; carbon nanotubes (CNTs), graphene, nanoclays, metal oxide nanoparticles, nanofibers and quantum dots; dispersion mechanisms; interfacial phenomena; structure–property relationships; advantages and limitations of polymer nanocomposites.

Number of Hours:09

Module-2

Synthesis and Processing Techniques

Preparation methods of polymer nanocomposites; solution blending; melt blending; in-situ polymerization; electrospinning; sol-gel processing; layer-by-layer assembly; extrusion and injection molding; additive manufacturing and 3D printing of polymer nanocomposites; functionalization of nanofillers; dispersion and compatibility enhancement techniques; scale-up and manufacturing challenges.

Number of Hours:09

Module-3

Functional Polymer Nanocomposites

Conductive and semiconductive polymer nanocomposites; electromagnetic interference (EMI) shielding materials; self-healing nanocomposites; smart and responsive polymer systems; shape-memory polymer nanocomposites; flame-retardant nanocomposites; biomedical polymer nanocomposites; antimicrobial materials; nanocomposites for sensors, actuators and flexible electronics; multifunctional nanocomposite systems.

Number of Hours:08

Module-4

Property Engineering of Polymer Nanocomposites

Interfacial interactions and adhesion mechanisms in polymer nanocomposites; filler dispersion and percolation phenomena; crystallization behavior and nucleation effects; mechanical reinforcement mechanisms; thermal stability and flame-retardant behavior; electrical conductivity and dielectric response; electromagnetic interference (EMI) shielding properties; barrier and transport properties; multifunctional property optimization;

Number of Hours:08

Module-5

Applications and Emerging Trends

Polymer nanocomposites for aerospace and automotive industries; energy storage and conversion applications; batteries, supercapacitors and fuel cells; packaging materials; environmental remediation; water purification membranes; biomedical implants and drug delivery systems; wearable electronics; sustainable and biodegradable nanocomposites; recycling and environmental aspects; modeling and simulation of polymer nanocomposites; future directions and industrial commercialization.

Number of Hours:08

Textbooks:

1. Introduction to Polymer Nanocomposites, Wiley.
2. Polymer Nanocomposites: Processing, Characterization and Applications, McGraw-Hill.

Reference books / Manuals:

1. Functional Polymer Nanocomposites, CRC Press.
2. Advanced Polymer Nanocomposites, Wiley.

Web links and Video Lectures (e-Resources):

1. https://materialsproject.org?utm_
2. https://pubs.acs.org?utm_

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Course Outcomes

1. Explain the fundamental concepts, classification, and structure–property relationships of polymer nanocomposites.
2. Apply appropriate synthesis, processing, and nanofiller functionalization techniques for developing polymer nanocomposites.
3. Analyze the structural, thermal, mechanical, electrical, and morphological properties of polymer nanocomposites using advanced characterization techniques.
4. Evaluate multifunctional polymer nanocomposites for smart materials, sensors, biomedical devices, and electronic applications.
5. Assess the suitability of advanced polymer nanocomposites for industrial, energy, environmental, and sustainable engineering applications.

Mappingof COSandPOs

COs \ POs	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

Carbon Based Nanostructures			
Course Code	**1MNST206A**	Scheme	2026
Type of Course	PEC-IV	Semester	2
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:0:48	SEE Marks	50
Credits	03	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Objectives

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

1. To understand the structure, classification, synthesis, and growth mechanisms of carbon nanotubes and related carbon nanostructures.
2. To study the synthesis, processing, and characterization techniques of graphene and graphene-based materials.
3. To analyze the structure, properties, and applications of fullerenes, nanodiamonds, and other carbon nanostructures.
4. To explore chemical functionalization techniques for tailoring the properties of carbon nanomaterials.
5. To evaluate the electronic, optical, mechanical, and energy-related applications 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.

Number of Hours:09

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 modifiedgraphene, electrochemical synthesis and other methods.

Number of Hours:09

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.

Number of Hours:08

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, additionof radicals,sidewall functionalization through electorphilic addition, nano covalent exohedralfunctionalization, endohedro functionalization.

Number of Hours:08

Module-5

Properties of Carbon nanostructure: Electronic, Vibrational, Mechanical Properties of CNTs, optical properties & Raman spectroscopy of CNTs.Application of Carbon nanostructure in Lithium ion battery, fuel cells, hydrogen storage, sensor applications, applications to nanoelectronics, nanocomposites, nanowires in drug delivery, polymer reinforcement and as filler materials

Number of Hours:08

Textbooks:

1. Carbon Nanotubes: Properties and Applications, CRC Press.
2. Carbon Nanotubes and Graphene, Elsevier.
3. Introduction to Carbon Nanomaterials, CRC Press.

Reference books / Manuals:

1. Physical Properties of Carbon Nanotubes, Imperial College Press.
2. Carbon Nanomaterials: Synthesis, Structure, Properties and Applications, CRC Press.
3. Graphene: Fundamentals and Emergent Applications, Elsevier.
4. Fullerenes: Principles and Applications, Royal Society of Chemistry.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/@nptelhrd?utm_source=chatgpt.com
2. https://www.youtube.com/@mitocw?utm_source=chatgpt.com

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Course Outcomes

1. Explain the structure, classification, synthesis methods, growth mechanisms, and characterization techniques of carbon nanotubes and related carbon nanostructures
2. Analyze graphene synthesis routes, structural features, and processing techniques for advanced applications
3. Evaluate the properties and applications of fullerenes, nanodiamonds, carbon clusters, and other carbon nanostructures.
4. Apply covalent and non-covalent functionalization approaches to modify carbon nanostructures for targeted applications.

5. Assess the electronic, optical, mechanical, and energy-storage applications of carbon nanostructures in advanced technologies.

Mappingof COSandPOs

COs \ POs	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

Nano materials for Energy Generation and Storage			
Course Code	**1MNST206B**	Scheme	2026
Type of Course	PEC-IV	Semester	2
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:0:48	SEE Marks	50
Credits	03	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Objectives

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

1. To understand the role of nanomaterials and nanostructures in renewable energy generation and harvesting technologies.
2. To study advanced energy storage systems including batteries and their nanomaterial-based components.
3. To analyze electrochemical energy storage mechanisms and nanostructured materials for supercapacitors.
4. To explore hydrogen production, storage technologies, and nanomaterials for hydrogen economy applications.
5. To evaluate fuel cell technologies, materials, fabrication methods, and emerging clean energy solutions.

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.

Number of Hours:09

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 ionbattery. LIB for automobiles application, EV's, HEV, PHEV and power grid.

Number of Hours:09

Module-3

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

Number of Hours:08

Module-4

Hydrogen Generation and storage technology: Hydrogen production methods, Electrochemical and photocatalytic H2 Generation using Nanomaterials, purification, hydrogen storage methods and materials: metal hydrides and metal organic framework materials, volumetricand gravimetric storagecapacities, hydriding and dehydriding kinetics.

Number of Hours:08

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.

Number of Hours:08

Textbooks:

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 books / Manuals:

1. Physical Properties of Carbon Nanotubes, Imperial College Press.
2. Carbon Nanomaterials: Synthesis, Structure, Properties and Applications, CRC Press.
3. Graphene: Fundamentals and Emergent Applications, Elsevier.
4. Fullerenes: Principles and Applications, Royal Society of Chemistry.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/@nptelhrd?utm_source=chatgpt.com
2. https://www.youtube.com/@mitocw?utm_source=chatgpt.com
3. https://www.youtube.com/@NRELgov?utm_source=chatgpt.com

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Course Outcomes

1. Explain renewable energy technologies and the role of nanomaterials in solar energy harvesting and conversion systems.
2. Analyze the design, operation, and performance of conventional and next-generation battery technologies employing nanostructured materials.
3. Evaluate electrochemical energy storage mechanisms and nanomaterials used in supercapacitors and hybrid energy storage devices.

4. Assess hydrogen generation, purification, storage methods, and nanomaterial-based hydrogen storage systems.
5. Investigate fuel cell technologies, materials, fabrication methods, and their applications in sustainable energy systems.

Mappingof COSandPOs

COs \ POs	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

Nanobiotechnology & Drug Delivery Systems			
Course Code	**1MNST206C**	Scheme	2026
Type of Course	PEC-IV	Semester	2
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:0:48	SEE Marks	50
Credits	03	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Objectives

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

1. To understand the design, synthesis, and characterization of nanoscale drug delivery systems.
2. To study smart nanomaterials and stimuli-responsive systems for targeted and controlled drug delivery.
3. To explore the role of nanotechnology in drug discovery, cancer therapy, and precision medicine.
4. To understand nanomedicines, diagnostic tools, and therapeutic applications of nanobiotechnology.
5. To analyze nanomaterials and nanotechnology-based approaches used in bioanalytics and molecular imaging.

Module-1

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.

Number of Hours:09

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.

Number of Hours:09

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 nanoparticlesin drugs discovery. Nanotechnology forCancer therapy-Nanobodies,Nanoparticles, nanoshells, Nanobombs, pebbles for brain tumor therapy, Targeting through angiogenesis and Folate Receptors Liposomal formulation in cancer therapy

Number of Hours:08

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 obacteria.

Number of Hours:08

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.

Number of Hours:08

Textbooks:

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 / Manuals:

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

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Course Outcomes

1. Explain the structure, preparation methods, and applications of various nanoscale drug carriers for therapeutic delivery.
2. Analyze smart and stimuli-responsive nanomaterials for controlled and targeted drug delivery applications.
3. Evaluate nanotechnology-based approaches in drug discovery, cancer diagnosis, and cancer therapy.
4. Assess the design, development, and biomedical applications of nanomedicines and nanodiagnostic systems.
5. Investigate the use of nanomaterials in bioanalytics, molecular labeling, bioimaging, and biosensing applications.

Mappingof COSandPOs

COs \ POs	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

Nanoelectronics, Spintronics & Quantum Devices			
Course Code	**1MNST206D**	Scheme	2026
Type of Course	PEC-IV	Semester	2
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:0:48	SEE Marks	50
Credits	03	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Objectives

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

1. To understand the principles of nanoelectronics and nanoscale device operation beyond conventional CMOS technologies.
2. To study advanced nanomaterials and emerging nanoelectronic devices used in next-generation electronic systems.
3. To analyze spin-dependent transport phenomena and spintronic device architectures.
4. To explore memory and logic applications based on spintronic technologies.
5. To understand quantum devices, quantum computing concepts, and emerging paradigms in nanoelectronics.

Module-1

Fundamentals of Nanoelectronics

Introduction to nanoelectronics; evolution of nanoelectronic devices; technology roadmap and scaling challenges; Moore's law and its limitations; More-Moore and More-than-Moore technologies; quantum mechanics for nanoelectronics; density of states in low-dimensional systems; quantum confinement effects; charge transport in nanoscale devices; tunneling phenomena; Coulomb blockade; review of nanoscale MOSFETs, FinFETs and Gate-All-Around FETs; emerging nanoelectronic materials and device architectures.

Number of Hours:09

Module-2

Advanced Nanoelectronic Materials and Devices

Carbon nanotubes (CNTs) and CNTFETs; graphene and graphene-based transistors; two-dimensional materials (MoS_2, WS_2, h-BN and related materials); nanowire transistors; Tunnel Field Effect Transistors (TFETs); single-electron transistors (SETs); resonant tunneling diodes (RTDs); device fabrication techniques; transport mechanisms in low-dimensional materials; performance metrics and reliability issues in nanoelectronic devices.

Number of Hours:09

Module-3

Fundamentals of Spintronics

Introduction to spintronics; electron spin and magnetic moment; spin polarization and spin transport; spin injection and detection; giant magnetoresistance (GMR); tunneling magnetoresistance (TMR); spin-dependent transport mechanisms; magnetic tunnel junctions (MTJs); spin valves; spin torque and spin transfer torque (STT); spin relaxation and coherence; materials for spintronic devices; spintronic sensors and memory technologies.

Number of Hours:08

Module-4

Spintronic Memory and Logic Devices

Magnetic Random Access Memory (MRAM); Spin Transfer Torque MRAM (STT-MRAM); Spin

Orbit Torque (SOT) devices; domain wall devices; racetrack memory; spin-based logic circuits; spin diodes and spin transistors; ferroelectric memories; spintronic interconnects; low-power computing architectures; fabrication and characterization of spintronic devices; applications in high-speed and non-volatile memory systems.

Number of Hours:08

Module-5

Quantum Devices and Emerging Computing Paradigms

Quantum confinement and quantum wells; quantum wires and quantum dots; quantum dot transistors; single-electron devices; quantum tunneling devices; qubits and quantum information processing; superconducting quantum devices; quantum computing fundamentals; quantum sensors; neuromorphic devices and memristors; hybrid quantum-nanoelectronic systems; challenges, scalability and future directions of quantum technologies.

Number of Hours:08

Textbooks:

1. Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices, 3rd Edition, Wiley-VCH Verlag GmbH & Co. KGaA, Germany, 2012.
2. Introduction to Spintronics, 2nd Edition, CRC Press, Taylor & Francis Group, Boca Raton, Florida, USA, 2016.
3. Quantum Transport: Atom to Transistor, Cambridge University Press, Cambridge, United Kingdom, 20

Reference books / Manuals:

1. Spintronics for Next Generation Innovative Devices, Wiley, 2015.
2. Electronic Transport in Mesoscopic Systems, Cambridge University Press, Cambridge, United Kingdom, 1997.
3. Quantum Computation and Quantum Information, 10th Anniversary Edition, Cambridge University Press, Cambridge, United Kingdom, 2010.
4. Carbon Nanotubes and Graphene for Nanoelectronics, Artech House Publishers, Norwood, Massachusetts, USA, 2011.

Web links and Video Lectures (e-Resources):

1. https://ieeemagnetics.org?utm_source
2. https://www.youtube.com/@nptelhrd?utm_source
3. https://learning.quantum.ibm.com?utm_source

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Course Outcomes

1. Explain the principles of nanoelectronics, quantum confinement, and nanoscale transport mechanisms.
2. Analyze the operation and performance of advanced nanoelectronic devices based on CNTs, graphene, 2D materials, and tunneling phenomena.
3. CO3: Evaluate spin transport mechanisms and the operation of spintronic devices such as GMR, TMR, and MTJs.
4. Design and assess spintronic memory and logic devices for low-power and non-volatile computing applications.
5. Investigate quantum devices, quantum computing architectures, and emerging nanoelectronic technologies.

Mappingof COSandPOs

COs \ POs	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

Research Methodology, Scientific Writing and Intellectual Property Rights (IPR) Lab			
Course Code	**1MNSTL207**	Scheme	2026
Type of Course	Ability Enhancement Course Lab	Semester	2
Teaching Hours/Week (L:T: P)	0:0 :30	CIE Marks	50
Total Hours of PedagogyL :T:P:SL:TW	0:0 :28:02	SEE Marks	50
Credits	01	Total Marks	100
Type of Examination	Practical	Exam Hours	3

Course outcome (Course Skill Set)

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

1. To develop skills in conducting systematic literature reviews and scientific information retrieval using research databases.
2. To impart knowledge of scientific writing, publication ethics, and technical documentation practices.
3. To train students in data analysis, visualization, and interpretation of research results.
4. To provide practical exposure to intellectual property rights, patent search, prior-art analysis, and patent drafting.
5. To enable students to prepare research proposals, technical presentations, journal manuscripts, and conference publications in the field of nanotechnology.

List of experiments

1. Conduct a comprehensive literature survey on perovskite solar cells using Scopus and Web of Science databases and analyze publication trends.
2. Perform bibliometric analysis of nanotechnology research publications using VOSviewer to generate author, citation, and keyword networks.
3. Create and manage a scientific reference database using Mendeley and generate citations and bibliographies in IEEE and APA formats.
4. Conduct prior-art and patent searches on carbon nanotube-based sensors using Google Patents, WIPO Patentscope, and Espacenet databases.
5. Draft a patent disclosure document for a nanotechnology-based innovation including abstract, claims, novelty, and applications.
6. Prepare a technical research manuscript on a selected nanotechnology topic following standard journal formatting guidelines.
7. Evaluate a scientific manuscript for plagiarism using plagiarism detection software and prepare an ethical publication compliance report.
8. Analyze experimental nanomaterial characterization data using OriginPro and generate publication-quality graphs, curve fitting, and statistical reports.
9. Prepare a complete research proposal including problem statement, objectives, methodology, timeline, budget, and expected outcomes.
10. Design and prepare a journal-ready manuscript and scientific conference poster based on experimental or simulation-based research findings.

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Research Methodology: Methods and Techniques, 3rd Edition, New Age International Publishers, New Delhi, 2019.
2. The Craft of Research, 4th Edition, University of Chicago Press, Chicago, USA, 2016.
3. Practical Research: Planning and Design, 12th Edition, Pearson Education, 2019.

Reference books / Manuals:

1. Publication Manual of the American Psychological Association, 7th Edition, APA Publications, Washington DC, USA, 2020.
2. Patent Searching Made Easy, Wiley Publications, 2007.
3. Scientific Writing and Communication: Papers, Proposals, and Presentations, 4th Edition, Oxford University Press, 2019.

Web links and Video Lectures (e-Resources):

1. Scopus Database
   https://www.scopus.com
2. Web of Science
   https://www.webofscience.com
3. Google Scholar
   https://scholar.google.com
4. Mendeley Reference Manager
   https://www.mendeley.com
5. VOSviewer Bibliometric Analysis Software
   https://www.vosviewer.com
6. Google Patents
   https://patents.google.com
7. WIPO PATENTSCOPE
   https://patentscope.wipo.int
8. Committee on Publication Ethics (COPE)
   https://publicationethics.org
9. NPTEL Online Courses
   https://nptel.ac.in
10. Elsevier Researcher Academy
   https://researcheracademy.elsevier.com

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

Course Outcomes

1. Conduct systematic literature surveys, bibliometric studies, and scientific information retrieval using advanced research databases.
2. Apply scientific writing, reference management, publication ethics, and technical documentation practices for research dissemination.
3. Analyze, interpret, and present scientific data using appropriate software tools and statistical techniques.
4. Perform patent searches, prior-art analysis, and prepare intellectual property documents related to nanotechnology innovations.
5. Develop research proposals, technical presentations, journal manuscripts, and conference publications demonstrating professional research competency.

CO-PO Mapping

COs / POs	PO1	PO2	PO3
CO1	3	2	2
CO2	2	3	2
CO3	3	2	3
CO4	3	3	2
CO5	3	3	3