Applied Mathematics			
Course Code	1MNT101	Scheme	2026
Type of Course	MAT/PCC	Semester	1
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. Toimpartknowledgeofvariousnumericalmethodstosolvetheproblems
2. Tounderstandadvancedlinearalgebraandnumerical/statisticalmethodsusedinchemicalengineering practice.
3. Tolearnmathematical/optimizationtechniquesrequiredtogetaninsightinvariousnanomaterials application.

Module-1

OrdinaryandPartialDifferentialEquations

Simultaneous first order linear equations with constant coefficients – linear equations of second order with constant and variable coefficients – Formation of partial differential equations – Classification of second order partial differential equations

Number of Hours:09

Module-2

Solution of Systems of Linear Equations

Partition method, Croute's Triangularisation method. Eigen values and Eigen vectors. Bounds on Eigen Values. Jacobi method for symmetric matrices.

Number of Hours:09

Module-3

OrtoganalityandLeastSquarers

Orthogonalvectors,orthogonalbases,orthonormalsets,orthogonalprojection,QRfactorization.Gram-Schmidt orthogonalization process and Applications to linear models- Least squares lines

Number of Hours:08

Module-4

ProbabilityTheory

Probability:Randomvariables,Probabilitydistributions:Binomial,Poisson,Normaldistributions,Jointprobability distribution (discrete)- examples.

Number of Hours:08

Module-5

Sampling Theory

Samplingdistributions-Testsbasedont-distribution,chi-squareandF-distributions-Analysisofvariance-One-wayandtwo-wayclassifications.

Number of Hours:08

Textbooks:

1. SankaraRaoK,“IntroductiontoPartialDifferentialEquations”,PHI,NewDelhi,2003.
2. DavidC.Lay,StevenR.Lay and J. J. McDonald:LinearAlgebra anditsApplications,5th Edition, Pearson Education Ltd., 2015.
3. MKJain,S.R.KIyengar,RK.Jain,NumericalMethodsforScientificand Engg. Computation, New Age International, 2003

Reference books / Manuals:

1. Gupta.S.C,andKapoor.V.K,“FundamentalsofMathematicalStatistics”,SultanChandandSons, New Delhi, 1999.
2. Kapoor.V.K,“Statistics(ProblemsandSolutions)”,SultanChandandSons,NewDelhi,1994

Web links and Video Lectures (e-Resources):

1. PhysicalMethods:Dr.R.Nagarajan,DepartmentofChemicalEngineering,IITMadras:https://www.youtube.com/watch?v=WK9i1F4fOik
2. ChemicalMethods:IITKanpur:https://www.youtube.com/watch?v=evE08ycZfnM
3. CombustionandSolutionMethods:IITKanpur:https://www.youtube.com/watch?v=WHF4k-x2NLU
4. BiologicalMethods:IITRoorkee:https://www.youtube.com/watch?v=0md5JdAbj4U
5. Surface Modification of Nanoparticles: Prof. Kaushik Pal, IIT Roorkee: https://www.youtube.com/watch?v=YsFw9SI3xV4

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 basic concepts will enable the students to apply mathematical models for solving problems in nanotechnology.
2. Solve system of linear equations using direct and iterative methods.
3. Apply the technique of least square approximation in solving inconsistent linear
4. systems.
5. Demonstrate a systematic knowledge of the mathematics for Nanotechnology applications.

Mappingof COSandPOs

	PO1	PO2	PO3
CO1	2	-	3
CO2	2	-	3
CO3	3	-	3
CO4	2	-	3
CO5	2	-	3

Introduction to Nano Technology			
Course Code	1MNT102	Scheme	2026
Type of Course	**MAT/PCC**	Semester	1
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. Introduce fundamental concepts and principles of nanotechnology.
2. Explain synthesis and fabrication techniques of nanomaterials.
3. Familiarize students with characterization methods for nanostructures.
4. Understand size-dependent properties of nanomaterials.
5. Explore applications of nanotechnology in various engineering and scientific domains.

Module-1

Historical development of nanoscience and nanotechnology, Length scales and nanoscale dimensions, Classification of nanomaterials: 0D, 1D, 2D, and 3D nanostructures, Quantum confinement and surface effects, Nanotechnology roadmap and emerging trends, Ethical, societal, and environmental aspects of nanotechnology Number of

Hours:09

Module-2

Top-down and bottom-up approaches, Mechanical milling and lithography techniques
Sol-gel synthesis, Chemical vapor deposition (CVD), Physical vapor deposition (PVD), Hydrothermal and solvothermal methods, Self-assembly techniques, Green synthesis of nanomaterials

Number of Hours:09

Module-3

X-ray Diffraction (XRD),Scanning Electron Microscopy (SEM) , Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM) , Scanning Tunnelling Microscopy (STM) UV-Visible spectroscopy, Raman spectroscopy, Dynamic Light Scattering (DLS)

Number of Hours:08

Module-4

Size-dependent properties, Electronic properties and quantum effects , Optical properties and plasmonic, Magnetic properties of nanoparticles, Mechanical properties and nanocomposites, Thermal properties of nanomaterials, Surface chemistry and catalytic activity

Number of Hours:08

Module-5

Nanotechnology in electronics and sensors, Nanomedicine and drug delivery systems, Nanotechnology in energy storage and conversion, Environmental remediation and water purification, Nanomaterials for aerospace and automotive applications, Smart materials and wearable devices, Future directions and challenges in nanotechnology

Number of Hours:08

Textbooks:

1. Introduction to Nanotechnology, Charles P. Poole Jr. and Frank J. Owens, CRC Press, 2nd Edition.
2. Nanotechnology: Principles and Practices, Sulabha K. Kulkarni, Springer, 4th Edition.
3. Nanoscience and Nanotechnology: Fundamentals to Frontiers, Wiley India.

Reference books / Manuals:

4. Nanotechnology: A Gentle Introduction to the Next Big Idea, Pearson Education.
5. Introduction to Nanoscience, CRC Press.
6. Nano: The Essentials, McGraw-Hill Education.
7. Nanomaterials: Synthesis, Properties and Applications, Institute of Physics Publishing.

Web links and Video Lectures (e-Resources):

1. **SWAYAM** – https://swayam.gov.in
   Courses on nanotechnology, materials science, and advanced manufacturing.
2. **Coursera** – https://www.coursera.org
   Nanotechnology-related courses offered by leading universities worldwide.
3. **edX** – https://www.edx.org
   Online courses in nanoscience, nanomaterials, and advanced engineering technologies.
4. **FutureLearn** – https://www.futurelearn.com
   Short courses on nanotechnology and emerging technologies.

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 fundamentals of nanoscience and nanotechnology and their significance in modern technology.
2. Classify nanomaterials and describe various synthesis and fabrication techniques.
3. Analyze nanomaterials using advanced characterization techniques.
4. Interpret the size-dependent physical, chemical, optical, and mechanical properties of nanomaterials.
5. Evaluate the applications and future prospects of nanotechnology in engineering,

healthcare, energy, and environmental sectors.

Mappingof COSandPOs

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

Materials Science and Properties of Nanomaterials			
Course Code	1MNT103	Scheme	2026
Type of Course	**MAT/PCC**	Semester	1
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 fundamental principles of materials science and their relevance to nanomaterials.
2. Analyze crystal structures, defects, and phase transformations governing the behavior of nanomaterials.
3. Examine the unique mechanical, thermal, electrical, optical, and magnetic properties exhibited at the nanoscale.
4. Correlate processing, structure, and properties of advanced nanomaterials.
5. Evaluate the suitability of nanomaterials for applications in engineering, energy, healthcare, and environmental sectors.

Module-1

Fundamentals of Materials Science and Nanomaterials: Introduction to materials science and engineering, classification of engineering materials, atomic structure and bonding, crystal structures, crystallographic systems, unit cells, crystal imperfections, nanoscale dimensions, surface-to-volume ratio, size effects, and classification of nanomaterials including nanoparticles, nanowires, nanotubes, and nanofilms.

Hours:09

Module-2

Crystal Defects, Diffusion and Phase Transformations: Point defects, line defects, planar defects, grain boundaries and dislocations. Diffusion mechanisms in solids, Fick's laws of diffusion, nucleation and growth, phase diagrams, phase transformations, grain growth, and the influence of defects and microstructure on nanomaterial properties.

Number of Hours:08

Module-3

Mechanical properties

Nano size effect on strength, fracture toughness and fatigue behavior. Bulk Properties of Materials, electricalconductivity,Dielectric properties,Thermalproperties, thermalconductivity,heatcapacity.Magneticproperties

Number of Hours:08

Module-4

ElectronicandOpticalProperties:

Electronic structure of Nanomaterials, magic numbers, Fermi surface, Size effect on Electron-Phonon Coupling, Size effect on physical properties.Optical properties, Optoelectronicproperties of bulk and nanostructures, relation between optical propertiesandelectronicstructureofnanomaterials–CatalyticpropertyCatalysisbyGoldNanoparticles

Number of Hours:08

Module-5

Advanced Nanomaterials and Applications: Carbon nanotubes, graphene, quantum dots, nanowires, nanocomposites, functional nanomaterials, structure-property relationships, applications in nanoelectronics, sensors, energy storage and conversion devices, catalysis, environmental remediation, biomedical engineering, drug delivery systems, tissue engineering, smart materials, and future trends in nanotechnology.Number of Hours:08

Textbooks:

1. William D. Callister Jr. and David G. Rethwisch, *Materials Science and Engineering: An Introduction*, Wiley, 10th Edition.
2. Charles P. Poole Jr. and Frank J. Owens, *Introduction to Nanotechnology*, CRC Press, 2nd Edition.
3. M. S. Ramachandra Rao and Shubra Singh, *Nanoscience and Nanotechnology: Fundamentals to Frontiers*, Wiley India.

Reference books / Manuals:

1. T. Pradeep, *Nano: The Essentials*, McGraw-Hill Education.
2. G. L. Hornyak, H. F. Tibbals, J. Dutta and J. J. Moore, *Introduction to Nanoscience and Nanotechnology*, CRC Press.
3. Bharat Bhushan, *Handbook of Nanotechnology*, Springer.
4. C. N. R. Rao, A. Müller and A. K. Cheetham, *The Chemistry of Nanomaterials*, Wiley-VCH.
5. V. Raghavan, *Materials Science and Engineering: A First Course*, PHI Learning.

Web links and Video Lectures (e-Resources):

1. NPTEL – Materials Science and Engineering: https://nptel.ac.in
2. NPTEL – Nanomaterials and Nanotechnology: https://nptel.ac.in
3. MIT OpenCourseWare – Materials Science and Engineering: 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 fundamental concepts of materials science and the structure of nanomaterials.
2. Analyze crystal structures, defects, diffusion mechanisms, and phase transformations in nanomaterials.
3. Interpret the mechanical and thermal properties of nanomaterials and their dependence on nanoscale dimensions.
4. Evaluate the electrical, optical, and magnetic properties exhibited by nanostructured materials.
5. Assess advanced nanomaterials and their applications in engineering, healthcare, energy, and environmental sectors.

Mappingof COSandPO

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

Characterisation Techniques for Nanomaterials Lab			
Course Code	**1MNT104A**	Scheme	2026
Type of course	**Integrated Professional Core Course (IPCC)**	Semester	1st
Teaching Hours/Week (L:T:P)	3:0:2	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	40:0:28 :26 :26	SEE Marks	50
Credits	**04**	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set)

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

1. Explain the principles and working mechanisms of advanced characterization techniques used for nanomaterials.
2. Analyze structural, morphological, compositional, and surface properties of nanomaterials using microscopy and spectroscopy methods.
3. Interpret characterization data obtained from XRD, SEM, TEM, AFM, STM, and spectroscopic techniques.
4. Evaluate the suitability of characterization methods for different classes of nanomaterials and applications.
5. Demonstrate practical skills in sample preparation, instrumentation, data acquisition, and interpretation through laboratory experiments.

Module-1

Introduction to Characterization Techniques and Structural Analysis: Importance of characterization in nanotechnology, structure-property relationships, crystallography fundamentals, crystal systems, Miller indices, X-ray generation and interaction with matter, principles of X-ray Diffraction (XRD), Bragg's law, phase identification, crystallite size determination using Scherrer equation, applications and limitations of XRD in nanomaterial characterization.

Number of Hours: 09

Module-2

Electron Microscopy Techniques: Fundamentals of electron-matter interactions, electron optics, Scanning Electron Microscopy (SEM), instrumentation, image formation, surface morphology analysis, Energy Dispersive X-ray Spectroscopy (EDS/EDX), principles and applications. Transmission Electron Microscopy (TEM), selected area electron diffraction (SAED), high-resolution TEM (HRTEM), sample preparation techniques, advantages and limitations.

Number of Hours: 09

Module-3

Scanning Probe Microscopy: Principles of Scanning Probe Microscopy (SPM), Atomic Force Microscopy (AFM), operating modes of AFM, force-distance measurements, surface roughness analysis, Scanning Tunneling Microscopy (STM), tunneling phenomenon, atomic-scale imaging, instrumentation, applications in nanotechnology, advantages and limitations of SPM techniques.

Number of Hours:08

Module-4

Spectroscopic Characterization Techniques: Fundamentals of spectroscopy, UV-Visible spectroscopy, absorption and transmission studies, photoluminescence spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR), Raman spectroscopy, surface-enhanced Raman scattering (SERS), elemental and chemical analysis, interpretation of spectroscopic data and applications in nanomaterials research.

Number of Hours:08

Module-5

Particle Size and Surface Characterization Techniques: Dynamic Light Scattering (DLS), particle size distribution analysis, zeta potential measurement, BET surface area analysis, thermal characterization using TGA and DSC, X-ray Photoelectron Spectroscopy (XPS), surface composition analysis, integrated characterization approaches and case studies on nanomaterials used in electronics, energy, biomedical, and environmental applications.

Number of Hours:08

PRACTICAL COMPONENTS OF IPCC

List of experiments

1. Determination of crystallite size and phase identification using X-ray Diffraction (XRD) data.
2. Calculation of lattice parameters, crystallinity index, and strain from XRD patterns.
3. Morphological analysis of nanomaterials using Scanning Electron Microscopy (SEM).
4. Elemental composition analysis of nanomaterials using Energy Dispersive X-ray Spectroscopy (EDS/EDX).
5. Surface topography and roughness measurement using Atomic Force Microscopy (AFM).
6. Atomic-scale imaging and tunneling current analysis using Scanning Tunneling Microscopy (STM) datasets.
7. Optical characterization of nanomaterials using UV–Visible Spectroscopy.
8. Determination of optical band gap of semiconductor nanomaterials using Tauc plot analysis.
9. Functional group and chemical bonding analysis using Fourier Transform Infrared (FTIR) Spectroscopy.
10. Thermal stability analysis of nanomaterials using Thermogravimetric Analysis (TGA)/Differential Scanning Calorimetry (DSC) data

Textbooks:

1. G. L. Hornyak, H. F. Tibbals, J. Dutta and J. J. Moore, *Introduction to Nanoscience and Nanotechnology*, CRC Press.
2. C. N. R. Rao, A. Müller and A. K. Cheetham, *The Chemistry of Nanomaterials*, Wiley-VCH.
3. Bharat Bhushan, *Springer Handbook of Nanotechnology*, Springer.

Reference books / Manuals

1. D. B. Williams and C. B. Carter, *Transmission Electron Microscopy: A Textbook for Materials Science*, Springer.
2. Joseph Goldstein et al., *Scanning Electron Microscopy and X-ray Microanalysis*, Springer.
3. S. Zhang and L. Li, *Nanostructures and Nanomaterials: Synthesis, Properties and Applications*, Imperial College Press.

Web links and Video Lectures (e-Resources):

1. NPTEL – Characterization of Materials: https://nptel.ac.in
2. NPTEL – Nanomaterials and Nanotechnology: https://nptel.ac.in
3. MIT OpenCourseWare – Materials Characterization: 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 a pass in the course.

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:

(i)Theory component

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

(ii) Laboratory component

Out of 25 marks, 15 marks shall be assigned for assessment of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.

The remaining 10 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 – ICs/IPCCs 1.

To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12 marks in the CIE Practical component.

Table – ICs/IPCCs 1 Distribution of marks corresponding to laboratory component

Component	**Description**	**Marks**
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	5 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	10 marks
	Subtotal	**15**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental	5

	procedure; ability to explain results and answer related questions.	marks
	Subtotal	**10**
	Total	**25**

Course Outcomes

1. Explain the principles and working mechanisms of advanced characterization techniques used for nanomaterials.
2. Analyze structural, morphological, compositional, and surface properties of nanomaterials using microscopy and spectroscopy methods.
3. Interpret characterization data obtained from XRD, SEM, TEM, AFM, STM, and spectroscopic techniques.
4. Evaluate the suitability of characterization methods for different classes of nanomaterials and applications.
5. Demonstrate practical skills in sample preparation, instrumentation, data acquisition, and interpretation through laboratory experiments.

Mappingof COSandPO

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

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Computational Nanotechnology & Simulation Lab			
Course Code	1MNT104B	Scheme	2026
Type of course	Integrated Professional Core Course (IPCC)	Semester	1st
Teaching Hours/Week (L:T:P)	3:0:2	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	40:0:28 :26 :26	SEE Marks	50
Credits	04	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set)

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

1. Understand the fundamentals of computational modeling and simulation in nanotechnology.
2. Develop nanoscale material and device models using COMSOL Multiphysics and MATLAB.
3. Analyze physical phenomena such as heat transfer, electrostatics, structural mechanics, and transport processes in nanostructures.
4. Apply numerical methods and finite-element techniques to solve nanotechnology-related problems.
5. Interpret simulation results and optimize nanomaterial and nanodevice performance.

Module-1

Introduction to Computational Nanotechnology and MATLAB Fundamentals: Role of simulation in nanotechnology, computational approaches for nanoscale systems, introduction to MATLAB environment, matrix operations, numerical computation, data visualization, plotting techniques, MATLAB programming fundamentals, and applications in nanotechnology.

Number of Hours:

Module-2

Modeling and Analysis of Nanomaterials using MATLAB: Mathematical modeling of nanoscale systems, simulation of particle size distribution, surface area calculations, quantum confinement effects, numerical solutions to nanotechnology problems, data fitting, optimization techniques, and graphical interpretation of nanomaterial properties

Number of Hours:

Module-3

Introduction to COMSOL Multiphysics: Finite Element Method (FEM), COMSOL user interface, geometry creation, meshing techniques, physics selection, material property assignment, boundary conditions, solver settings, post-processing, and result visualization.

Number of Hours:

Module-4

Multiphysics Simulation of Nanostructures: Structural analysis of nanostructures, stress-strain behavior, heat transfer in nanomaterials, electrostatic field distribution, transport phenomena, coupled multiphysics simulations, and performance evaluation of nanoscale systems using COMSOL.

Number of Hours:

Module-5

Nanodevice Modeling and Optimization: Modeling of nanosensors, MEMS/NEMS devices, nanowire-based structures, microfluidic systems, nanoelectronic devices, optimization studies, parametric analysis, validation of simulation results, and engineering applications of computational nanotechnology.

Number of Hours:

PRACTICAL COMPONENTS OF IPCC

List of experiments

1. Introduction to MATLAB programming for nanotechnology applications.
2. Simulation and visualization of nanoparticle size distribution using MATLAB.
3. Numerical analysis of quantum confinement effects using MATLAB.
4. Data fitting and optimization of nanomaterial characterization data using MATLAB.
5. Creation of nanoscale geometries and meshing in COMSOL Multiphysics.
6. Structural analysis of nanostructures using COMSOL.
7. Heat transfer simulation in nanomaterials using COMSOL.
8. Electrostatic field analysis of nanosensors using COMSOL.
9. Multiphysics simulation of coupled thermal-electrical behavior in nanostructures.
10. Modeling and optimization of MEMS/NEMS or nanodevice structures using COMSOL Multiphysics.

Textbooks:

1. K. E. Brenan, *Numerical Methods for Engineers and Scientists Using MATLAB*, CRC Press.
2. Attaway Stormy, *MATLAB: A Practical Introduction to Programming and Problem Solving*, Butterworth-Heinemann.
3. COMSOL AB, *Introduction to COMSOL Multiphysics®*, COMSOL Documentation.

Reference books / Manuals

1. Supriyo Datta, *Quantum Transport: Atom to Transistor*, Cambridge University Press.
2. Richard LeSar, *Introduction to Computational Materials Science*, Cambridge University Press.
3. T. Pradeep, *Nano: The Essentials*, McGraw-Hill Education.
4. David K. Ferry, *Transport in Nanostructures*, Cambridge University Press.
5. COMSOL Multiphysics Application Library Documentation.

Web links and Video Lectures (e-Resources):

1. COMSOL Learning Center – https://www.comsol.com/learning-center
2. COMSOL Video Gallery – https://www.comsol.com/video
3. MATLAB Academy – https://matlabacademy.mathworks.com
4. MathWorks Documentation and Tutorials – https://www.mathworks.com/help
5. NPTEL – MATLAB Programming – https://nptel.ac.in
6. NPTEL – Numerical Methods and Simulation – https://nptel.ac.in
7. MIT OpenCourseWare – Computational Engineering – https://ocw.mit.edu
8. COMSOL Application Gallery –https://www.comsol.com/models

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 a pass in the course.

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:

(i)Theory component

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

(ii) Laboratory component

Out of 25 marks, 15 marks shall be assigned for assessment of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.

The remaining 10 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 – ICs/IPCCs 1.

To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12 marks in the CIE Practical component.

Table – ICs/IPCCs 1 Distribution of marks corresponding to laboratory component

Component	Description	Marks
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	5 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	10 marks
	Subtotal	**15**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	5 marks
	Subtotal	**10**
	Total	**25**

Course Outcomes

1. Explain the principles of computational modelling and simulation used in nanotechnology.
2. Develop MATLAB programs for solving nanotechnology-related numerical problems.
3. Create and analyze nanoscale models using COMSOL Multiphysics.
4. Simulate coupled physical phenomena in nanostructures using finite-element methods.
5. Evaluate and optimize the performance of nanomaterials and nanodevices through computational analysis.

Mappingof COSandPO

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

Energy Nanomaterials & Battery Technology Lab			
Course Code	**1MNT104C**	Scheme	2026
Type of course	Integrated Professional Core Course (IPCC)	Semester	1st
Teaching Hours/Week (L:T:P)	3:0:2	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	40:0:28 :26 :26	SEE Marks	50
Credits	04	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course Objectives

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

1. Understand the fundamentals of energy nanomaterials and their role in energy conversion and storage systems.
2. Analyze the synthesis, characterization, and performance evaluation of nanomaterials used in batteries and supercapacitors.
3. Study the electrochemical principles governing battery operation and energy storage mechanisms.
4. Evaluate advanced battery technologies, materials selection, and sustainability aspects of energy storage devices.
5. Develop practical skills in fabrication, characterization, and testing of battery materials and electrochemical systems.

Module-1

Fundamentals of Energy Nanomaterials

Introduction to global energy challenges and sustainable energy technologies. Fundamentals of nanomaterials, size-dependent properties, classification of nanomaterials, synthesis techniques (top-down and bottom-up approaches). Structural, electrical, optical, and thermal properties of energy nanomaterials. Applications of nanomaterials in renewable energy and energy storage systems.

Number of Hours: 09

Module-2

Nanomaterials for Electrochemical Energy Storage

Electrochemical principles and energy storage mechanisms. Electrode materials for batteries and supercapacitors. Carbon nanomaterials, graphene, carbon nanotubes, metal oxides, conducting polymers, and nanocomposites. Nanostructured cathode, anode, and electrolyte materials. Charge transport and ion diffusion in nanostructured materials.

Number of Hours: 08

Module-3

Battery Technologies and Materials

Fundamentals of battery operation. Lithium-ion batteries: working principle, materials, performance parameters. Sodium-ion, lithium-sulfur, lithium-air, and solid-state batteries. Battery design considerations, energy density, power density, cycle life, and safety aspects. Emerging battery technologies and current industrial trends.

Number of Hours:08

Module-4

Characterization and Performance Evaluation

Structural characterization using XRD, SEM, TEM, and Raman spectroscopy. Surface and chemical analysis using EDS and XPS. Electrochemical characterization techniques: Cyclic Voltammetry (CV), Galvanostatic Charge-Discharge (GCD), Electrochemical Impedance Spectroscopy (EIS). Performance metrics and degradation analysis of battery materials

Number of Hours:08

Module-5

Advanced Energy Storage Systems and Sustainability

Flexible and wearable energy storage devices. Nanomaterials for hydrogen storage and fuel cells. Battery management systems (BMS). Recycling and sustainability of battery materials. Environmental impact assessment, circular economy concepts, and future directions in energy storage technologies.

Number of Hours:08

PRACTICAL COMPONENTS OF IPCC

1. Synthesis of $LiFePO_4$ (LFP) Cathode Material using sol-gel or hydrothermal method.
2. Synthesis of Layered Oxide Cathode Materials (NMC – $LiNixMnyCozO_2$) and study of synthesis parameters.
3. Structural Characterization of LFP and NMC Materials using XRD and phase identification.
4. Morphological Analysis of Synthesized Cathode Materials using SEM image analysis.
5. Fabrication of Coin Cell/Swagelok Cell using synthesized electrode materials.
6. Battery Charge–Discharge Testing and determination of specific capacity, Coulombic efficiency, and cycle stability.
7. Calculation of Specific Capacitance, Energy Density, and Power Density from experimental electrochemical data.
8. Electrochemical Impedance Spectroscopy (EIS) Analysis and equivalent circuit modeling of battery cells.
9. Cyclic Voltammetry (CV) Analysis for evaluating electrochemical behavior and redox reactions.
10. Simulation of Lithium-Ion Battery Performance Using COMSOL Multiphysics.
11. Mini Project: Comparative Performance Evaluation of LFP and NMC Cathode Materials for Energy Storage Applications.

Textbooks:

1. C. Julien, A. Mauger, A. Vijh and K. Zaghib, *Lithium Batteries: Science and Technology*, Springer.
2. Vladimir G. Chigrinov, *Nanomaterials for Energy Storage Applications*, CRC Press.
3. Feng Li and Yushin, *Nanostructured Materials for Electrochemical Energy Production and Storage*, Springer.
4. M. Stanley Whittingham, *Lithium Batteries and Other Electrochemical Storage Systems*, Wiley.

<u>Reference books / Manuals</u>

1. A.J. Bard and L.R. Faulkner, *Electrochemical Methods: Fundamentals and Applications*, Wiley.
2. Jiujun Zhang, *Nanomaterials for Energy Storage and Conversion*, Wiley.
3. Reza Moheimani and Franky So, *Energy Materials Fundamentals to Applications*, Springer.
4. Bruce Dunn, *Electrical Energy Storage for the Grid: A Battery of Choices*, MIT Press.
5. COMSOL Multiphysics User Manual for Electrochemistry Module.
6. MATLAB Documentation for Battery Modeling and Simulation.

Web links and Video Lectures (e-Resources):

1. NPTEL Courses on Energy Storage Systems
2. COMSOL Multiphysics Learning Center
3. MATLAB Battery Systems Resources
4. MIT OpenCourseWare – Electrochemical Energy Systems

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 a pass in the course.

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:

(i)Theory component

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

(ii) Laboratory component

Out of 25 marks, 15 marks shall be assigned for assessment of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.

The remaining 10 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 – ICs/IPCCs 1.

To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12 marks in the CIE Practical component.

Table – ICs/IPCCs 1 Distribution of marks corresponding to laboratory component

Component	**Description**	**Marks**
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	5 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	10 marks
	Subtotal	**15**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental	5

	procedure; ability to explain results and answer related questions.	marks
	Subtotal	**10**
	Total	**25**

Course Outcomes

1. Explain the fundamental concepts, properties, and synthesis methods of energy nanomaterials.
2. Analyze the role of nanomaterials in electrochemical energy storage devices and battery systems.
3. Evaluate the performance of various battery technologies and select suitable materials for energy storage applications.
4. Apply characterization and electrochemical analysis techniques to assess battery material performance.
5. Design, simulate, and assess advanced energy storage systems considering sustainability and future technological trends.

Mappingof COSandPO

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

Advanced Nanomaterials Synthesis Lab			
Course Code	**1MNT104D**	Scheme	2026
Type of course	Integrated Professional Core Course (IPCC)	Semester	1st
Teaching Hours/Week (L:T:P)	3:0:2	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	40:0:28 :26 :26	SEE Marks	50
Credits	04	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course Objectives

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

1. Understand advanced synthesis techniques for nanomaterials with controlled size, shape, composition, and functionality.
2. Analyze the mechanisms governing nucleation, growth, and self-assembly of nanostructures.
3. Explore synthesis strategies for metallic, ceramic, polymeric, carbon-based, and hybrid nanomaterials.
4. Develop expertise in selecting appropriate synthesis routes for specific applications.
5. Gain practical experience in synthesizing and characterizing advanced nanomaterials.

Module-1

Fundamentals of Nanomaterial Synthesis

Introduction to nanomaterial synthesis; nucleation and growth theories; thermodynamics and kinetics of nanostructure formation; size and shape control; surface energy and crystal growth; self-assembly mechanisms; bottom-up and top-down fabrication approaches.

Number of Hours: 09

Module-2

Chemical Synthesis Techniques

Sol-gel synthesis, co-precipitation, hydrothermal and solvothermal methods, microemulsion techniques, chemical reduction methods, polyol process, sonochemical synthesis, microwave-assisted synthesis, template-assisted synthesis, advantages and limitations of various chemical routes.

Number of Hours: 08

Module-3

Physical and Vapor-Based Synthesis Methods

Physical vapor deposition (PVD), chemical vapor deposition (CVD), sputtering, pulsed laser deposition, molecular beam epitaxy, thermal evaporation, arc discharge method, laser ablation, synthesis of thin films and nanostructured coatings.

Number of Hours:08

Module-4

Advanced Nanostructures and Functional Materials

Synthesis of nanoparticles, nanowires, nanotubes, nanorods, quantum dots, graphene, carbon nanotubes, MXenes, metal-organic frameworks (MOFs), hybrid nanocomposites, core-shell nanostructures, and heterostructure materials.

Number of Hours:08

Module-5

Scale-Up, Sustainability and Applications

Scale-up challenges in nanomaterial production, green synthesis approaches, bio-inspired synthesis, process optimization, industrial production strategies, safety considerations, environmental impact, applications in energy storage, sensors, catalysis, biomedical devices, and electronics.

Number of Hours:08

PRACTICAL COMPONENTS OF IPCC

1. Synthesis of metal oxide nanoparticles using the sol-gel method.
2. Synthesis of ZnO nanoparticles by co-precipitation technique.
3. Hydrothermal synthesis of nanostructured materials.
4. Microwave-assisted synthesis of metal oxide nanomaterials.
5. Synthesis of graphene oxide and reduced graphene oxide.
6. Preparation of nanocomposites using Combustion methods.
7. Synthesis of ZnONP's by green route technique
8. Surface area estimation and porosity analysis from adsorption data.
9. Simulation of nanomaterial growth and transport phenomena using COMSOL Multiphysics.
10. Mini-project on synthesis optimization and characterization of functional nanomaterials.

Textbooks:

1. C. N. R. Rao, A. Müller and A. K. Cheetham, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Wiley-VCH.
2. Guozhong Cao and Ying Wang, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, World Scientific.

A. S. Edelstein and R. C. Cammarata, Nanomaterials: Synthesis, Properties and Applications, CRC Press.

3. Zhong Lin Wang, Characterization of Nanophase Materials, Wiley-VCH.
4. Reference books / Manuals

<u>Reference books / Manuals</u>

1. T. Pradeep, A Textbook of Nanoscience and Nanotechnology, McGraw-Hill.
2. Bharat Bhushan, Springer Handbook of Nanotechnology, Springer.
3. Hari Singh Nalwa, Handbook of Nanostructured Materials and Nanotechnology, Academic Press.
4. C. Dupas, P. Houdy and M. Lahmani, Nanoscience: Nanotechnologies and Nanophysics, Springer.
5. COMSOL Multiphysics® Documentation and Application Library

Web links and Video Lectures (e-Resources):

1. NPTEL Nanotechnology Courses
2. NanoHub Simulation Resources
3. COMSOL Learning Center

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 a pass in the course.

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:

(i)Theory component

The CIE marks of 25 shall be earmarked for two tests.
The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.
Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

(ii) Laboratory component

Out of 25 marks, 15 marks shall be assigned for assessment of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.
The remaining 10 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 – ICs/IPCCs 1.
To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12 marks in the CIE Practical component.

Table – ICs/IPCCs 1 Distribution of marks corresponding to laboratory component		
Component	**Description**	**Marks**
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	5 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	10 marks
	Subtotal	**15**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	5 marks
	Subtotal	**10**
	Total	**25**

Course Outcomes

1. Analyze the principles governing nucleation, growth, and self-assembly in advanced nanomaterial synthesis.
2. Select and implement suitable chemical and physical synthesis routes for producing nanomaterials with desired properties.
3. Design and optimize synthesis parameters to achieve controlled nanostructures for targeted applications.
4. Evaluate the structural, morphological, and functional characteristics of synthesized nanomaterials using advanced characterization techniques.
5. Develop sustainable and scalable nanomaterial synthesis strategies for industrial and research applications.

Mappingof COSandPO

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

Nanomaterials Synthesis & Processing			
Course Code	**1MNT105A**	Scheme	2026
Type of Course	Professional Elective Courses-I (PEC)	Semester	1
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 fundamental concepts of nanomaterial processing, colloidal systems, and process–structure–property relationships.
2. Explore advanced synthesis and processing techniques including combustion, solution, biological, and nanocomposite fabrication methods.
3. Analyze the mechanisms governing the formation, growth, and functionalization of nanostructures.
4. Investigate surface engineering approaches for controlling nanoparticle dispersion, stability, and functionality.
5. Develop research-oriented skills for designing and processing nanomaterials for advanced technological applications.

Module-1

Nanomaterial Processing Fundamentals

Introduction to nanomaterial processing; process–structure–property relationships; powder processing fundamentals; particle packing and agglomeration; dispersion and stabilization of nanoparticles; rheology of nanoparticle suspensions; colloidal processing principles.

Number of Hours: 09

Module-2

Nanocomposite and Functional Material Processing

Polymer nanocomposites; ceramic matrix nanocomposites; metal matrix nanocomposites; interface engineering; processing of graphene- and CNT-reinforced composites; functional coatings; flexible and wearable nanomaterial systems.

Number of Hours: 09

Module-3

CombustionandSolutionMethods:

Solution combustion process, spray pyrolysis method, flame spray pyrolysis, gas phase synthesis, gas condensation process, chemical vapour condensation. Fundamental aspects of VLS (Vapour-Liquid-Solid) and SLS (Solution-Liquid-Solid) processes – VLS growth of Nanowires – Control of the size of the nanowires – Precursors and catalysts – SLS growth – Stress induced recrystallization

Number of Hours:08

Module-4

Biologicalmethods:

Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Natural and artificial synthesis of nanoparticles in microorganisms; Use of microorganisms for nanostructure formation, Role of plants in nanoparticle synthesis, synthesis of nanoparticles using proteins and DNA templates.

Number of Hours:08

Module-5

Surface Modification of Nanoparticles

Introduction to Nanoparticles dispersion and aggregation behaviour, Surface interaction between nanoparticles, Difficulty in nanoparticle control based on DLVO theory. Effect of particle diameter and solid fraction on distance between the particle surface, Surface molecular level structure of Nanoparticles. Basic approach to
control nanoparticle dispersion behaviour. Surface modification of inorganic nanoparticles by organic functional groups –Organic modification of Metal, Metal oxide nanoparticles, hybridization of inorganic nanoparticles with biomolecules. Surface modification of Carbon Nanostructures.

Number of Hours:08

Textbooks:

1. Carl C. Koch, Nanostructured Materials: Processing, Properties and Applications, William Andrew Publishing.
2. Guozhong Cao and Ying Wang, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, World Scientific.
3. Guozhong Cao, "Nanostructures and Nanomaterials, synthesis, properties and applications", Imperial College Press, 2004
4. M.S. Ramachandra Rao, Shubra Singh, Nanoscience and Nanotechnology: fundamentals to Frontiers, Wiley2013.
5. IntroductiontoNanotechnology -CharlesP.PooleJr.andFranks.J.Qwens

Reference books / Manuals:

1. Nanomaterials–A.K.Bandyopadhyay,NewAgeInternationalPublishers,2ndEdition,2010
2. T.Pradeep,"NANOTheEssential,understandingNanoscienceandNanotechnology".TataMcGraw-Hill Publishing Company Limited, 2007.
3. C.A.MirkinandC.M.Niemeyer,Nanobiotechnology-II,MoreConceptsandApplications,WILEY-VCH, VerlagGmbH&Co, 2007.

Web links and Video Lectures (e-Resources):

1. PhysicalMethods:Dr.R.Nagarajan,DepartmentofChemicalEngineering,IITMadras:https://www.youtube.com/watch?v=WK9i1F4fOik
2. ChemicalMethods:IITKanpur:https://www.youtube.com/watch?v=evE08ycZfnM
3. CombustionandSolutionMethods:IITKanpur:https://www.youtube.com/watch?v=WHF4k-x2NLU
4. BiologicalMethods:IITRoorkee:https://www.youtube.com/watch?v=0md5JdAbj4U
5. Surface Modification of Nanoparticles: Prof. Kaushik Pal, IIT Roorkee: https://www.youtube.com/watch?v=YsFw9SI3xV4

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 nanomaterial processing, particle interactions, colloidal stability, and process–structure–property relationships.
2. Apply combustion, solution-based, and biological methods for the synthesis and processing of nanomaterials.
3. Analyze nanocomposite fabrication techniques and evaluate the influence of interfaces on material performance.
4. Assess nanowire growth mechanisms, nanoparticle formation processes, and advanced surface modification strategies.
5. Develop innovative and sustainable processing approaches for functional nanomaterials in engineering and biomedical applications.

Mappingof COSandPOs

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

Nanoelectronics & Device Fabrication			
Course Code	**1MNT105B**	Scheme	2026
Type of Course	Professional Elective Courses-I (PEC)	Semester	1
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 evolution of nanoelectronics and the limitations of conventional CMOS scaling.
2. Analyze the operation and performance challenges of nanoscale MOSFET devices.
3. Explore the design, fabrication, and modeling of FinFET-based digital circuits.
4. Investigate the structure, characteristics, and applications of CNTFET-based electronic devices.
5. Evaluate emerging nanoelectronic technologies including molecular electronics, spintronics, and advanced memory devices.

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 dielectricsand Gatestack, Future interconnect.Number of Hours: 09

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, Ballistictransport, Channel quantization.

Number of Hours: 09

Module-3

Designing with FINFETs

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

Number of Hours:08

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 usiCNTFETs,combinational and sequential circuits using CNTFETs, adders, multipliers and SRAM cell using CNTFETs. Number of Hours:08
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, -spindiodes - Magnetic tunnel transistor - Memory devices and sensors - ferroelectric random access memory- MRAMS Number of Hours:08

Textbooks:

1. Yuan Taur and Tak H. Ning, Fundamentals of Modern VLSI Devices, Cambridge
2. Karl Goser, Peter Glosekotter, Jan Dienstuhl, ―Nanoelectronics and Nanosystems‖, Springer (2004)
3. Cyril Prasanna Raj P., Designing with FINFETs and CNTFETs, MSEC E-Publication (2016)
4. SadamichiMaekawa, ―Concepts in Spin Electronics‖, Oxford University Press (2006)

Reference books / Manuals:

1. V. Mitin, V. Kochelap, M. Stroscio, Introduction to Nanoelectronics, Cambridge University Press (2008)
2. Edward L. Wolf, ―Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience‖, Wiley-VCH (2006)
3. Streetman and Banerjee, Solid State Electronic Devices, Prentice-Hall
4. Rainer Waser, ―Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices, Wiley-VCH

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses?utm_source=chatgpt.com
   https://ocw.mit.edu?utm_source=chatgpt.com
2. https://eds.ieee.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. Understand and appreciate the importance of nanoelectronics and its impact in next generation electronics and electronic products
2. Differentiate between MOS and emerging nanodevices technology, understand the advantages and limitations of MOS based circuits
3. Understand the technology migration from MOS to nano devices, process challenges and analyse the mathematical models for emerging Nanoscale devices
4. Design logic circuits, sub systems and complex digital circuits using FINFETs and CNTFETs
5. 5. Evaluate the advances in Nanoscale technology development and understand the importance of emerging devices and technologies of molecular electronics and spintronics

Mappingof COSandPOs

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

Nanobiotechnology & Biosensors			
Course Code	**1MNT105C**	Scheme	2026
Type of Course	Professional Elective Courses-I (PEC)	Semester	1
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 fundamental concepts of biotechnology and their integration with nanotechnology.
2. Explore biological molecules and cellular systems as templates for nanoscale engineering.
3. Analyze the synthesis, structure, and functionality of bio-inspired nanostructures and nano-bio assemblies.
4. Investigate the interactions between nanoparticles and biological systems for biomedical applications.
5. Evaluate emerging applications of nanobiotechnology in healthcare, diagnostics, drug delivery, and nanoelectronics.

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 buildingblocks; Sizesof buildingblocks and comparison with nanostructures.

Number of Hours: 09

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.

Number of Hours: 09

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 diagnosticsand Biotechnology, Currentstatus ofNanobiotechnology, Future perspectives of Nanobiology

Number of Hours:08

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.

Number of Hours:08

Module-5

Photoinduced Electron Transport in DNA

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

Number of Hours:08

Textbooks:

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 MelgardtM.deVilliers, PornanongAramwit, Glen S. Kwon, Springer-American Association of Pharmaceutical Scientists Press 2009.

Reference books / Manuals:

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):

1. https://nptel.ac.in/courses?utm_source
2. https://ocw.mit.edu?utm_source
3. https://eds.ieee.org?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 biotechnology, biomolecular systems, and biological building blocks relevant to nanotechnology.
2. Analyze DNA-, protein-, and biomolecule-based nanostructures and their applications in nanoscale engineering.
3. Evaluate interactions between nanoparticles and biomolecules for the development of hybrid nano-bio systems.
4. Apply nanobiotechnology concepts in drug delivery, biosensing, tissue engineering, and biomedical diagnostics.
5. Assess advanced applications of DNA-based nanoelectronics and emerging nanobiotechnological solutions for healthcare and technology.

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

Nanomaterials for Sensors & Actuators			
Course Code	**1MNT105D**	Scheme	2026
Type of Course	Professional Elective Courses-I (PEC)	Semester	1
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 principles and operating mechanisms of sensors and actuators based on nanomaterials.
2. Explore the role of nanostructured materials in enhancing sensing and actuation performance.
3. Analyze transduction mechanisms and signal processing in nanoscale sensing systems.
4. Investigate fabrication techniques and integration strategies for nanosensors and nanoactuators.
5. Evaluate emerging applications of nanomaterial-based sensors and actuators in healthcare, environmental monitoring, and smart systems.

Module-1

Fundamentals of Sensors, Actuators and Nanomaterials

Introduction to sensors and actuators; classification of sensors; sensing characteristics and performance parameters; transduction mechanisms; smart sensors; nanomaterials for sensing applications; quantum confinement effects; surface-to-volume ratio; nanostructured materials for sensing and actuation; MEMS and NEMS fundamentals.

Number of Hours: 09

Module-2

Nanomaterials for Sensing Applications

Metal oxide nanomaterials for gas sensing; carbon nanotubes, graphene, MXenes, quantum dots, nanowires, and nanocomposites for sensing applications; surface functionalization of nanomaterials; sensitivity, selectivity, response and recovery characteristics; sensor performance optimization.

Number of Hours: 09

Module-3

Nanosensors and Detection Mechanisms

Chemical sensors, gas sensors, humidity sensors, pressure sensors, temperature sensors, optical sensors, electrochemical sensors, biosensors; piezoresistive, piezoelectric, capacitive, optical, and electrochemical transduction mechanisms; nanoscale signal generation and processing; sensor calibration and reliability.

Number of Hours:08

Module-4

Nanoactuators and Smart Systems

Fundamentals of actuation; electrostatic, thermal, piezoelectric, magnetic, shape-memory, and polymer-based actuators; nanostructured piezoelectric materials; CNT- and graphene-based actuators; microactuators and nanoactuators; integration of sensors and actuators in smart systems; wearable and flexible devices.

Number of Hours:08

Module-5

Advanced Applications and Emerging Trends

Nanomaterial-based healthcare sensors; implantable and wearable sensors; environmental monitoring systems; Internet of Things (IoT)-enabled nanosensors; self-powered sensors; artificial skin and electronic skin; energy harvesting for sensor systems; intelligent sensing platforms; future directions in nanosensors and nanoactuators.

Number of Hours:08

Textbooks:

1. Julian W. Gardner, Vijay K. Varadan and Osama O. Awadelkarim, Microsensors, MEMS and Smart Devices, Wiley.
2. Vijay K. Varadan, Lin Feng and Krzysztof J. Vinoy, Nanotechnology: Applications in Engineering and Medicine, Wiley.
3. Bharat Bhushan, Springer Handbook of Nanotechnology, Springer.

Reference books / Manuals:

1. Sergey Edward Lyshevski, Nano and Molecular Electronics Handbook, CRC Press.
2. Tai-Ran Hsu, MEMS and Microsystems: Design and Manufacture, McGraw-Hill.
3. Gabriel M. Rebeiz, RF MEMS: Theory, Design and Technology, Wiley.
4. C.N.R. Rao and A. Muller, The Chemistry of Nanomaterials, Wiley-VCH.
5. Chang Liu, Foundations of MEMS, Pearson Education

Web links and Video Lectures (e-Resources):

1. https://nanohub.org?utm_source
2. https://nanohub.org?utm_source
3. https://ieee-sensors.org?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 operating principles, performance parameters, and transduction mechanisms of nanomaterial-based sensors and actuators.
2. Analyze the properties of nanomaterials and their influence on sensing and actuation performance.
3. Design and evaluate nanosensors and nanoactuators for specific engineering and biomedical applications.
4. Assess fabrication, integration, and reliability aspects of sensor-actuator systems using advanced nanomaterials.
5. Develop innovative sensor and actuator solutions for smart, wearable, environmental, and healthcare 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

Advanced Thin Film Technology & Surface Engineering			
Course Code	**1MNT106A**	Scheme	2026
Type of Course	Professional Elective Courses-II (PEC)	Semester	1
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 fundamental principles of thin film growth, surface phenomena, and interface engineering.
2. Analyze advanced deposition techniques used for the fabrication of functional thin films and coatings.
3. Investigate the influence of processing parameters on thin film microstructure, properties, and performance.
4. Evaluate surface modification and engineering approaches for improving material functionality.
5. Develop advanced thin-film-based solutions for applications in electronics, energy, biomedical devices, and protective coatings.

Module-1

Fundamentals of Thin Films and Surface Engineering

Introduction to thin films and coatings; surface and interface phenomena; surface energy and wettability; nucleation and growth mechanisms; thin film growth modes (Volmer-Weber, Frank-Van der Merwe, Stranski-Krastanov); film stress and adhesion; structure-property relationships in thin films.

Number of Hours: 09

Module-2

Thin Film Deposition Techniques

Physical Vapor Deposition (PVD): thermal evaporation, electron beam evaporation, sputtering, pulsed laser deposition. Chemical Vapor Deposition (CVD), plasma-enhanced CVD, atomic layer deposition (ALD), molecular beam epitaxy (MBE); process parameters and film quality control.

Number of Hours: 09

Module-3

Surface Modification and Engineering

Surface treatment techniques; plasma surface modification; ion implantation; laser surface engineering; surface texturing; self-assembled monolayers (SAMs); functionalization of metallic, ceramic, and polymer surfaces; corrosion and wear-resistant coatings.

Number of Hours:08

Module-4

Characterization of Thin Films and Surfaces

Thickness measurement techniques; profilometry; ellipsometry; X-ray reflectivity (XRR); structural characterization using XRD; surface morphology using SEM and AFM; chemical characterization using XPS and EDS; electrical, optical, and mechanical property evaluation.

Number of Hours:08

Module-5

Advanced Applications of Thin Films

Thin films for microelectronics and nanoelectronics; transparent conducting oxides; thin-film solar cells; magnetic and spintronic films; biomedical coatings; anti-reflective and self-cleaning coatings; MEMS/NEMS applications; emerging trends in smart and multifunctional surfaces.

Number of Hours:08

Textbooks:

1. Donald L. Smith, Thin-Film Deposition: Principles and Practice, McGraw-Hill.
2. Milton Ohring, Materials Science of Thin Films, Academic Press.
3. John A. Thornton and D.W. Hoffman, Thin Films for Advanced Technologies, Elsevier.

Reference books / Manuals:

1. Bharat Bhushan, Springer Handbook of Nanotechnology, Springer.
2. Leonard I. Maissel and Reinhard Glang, Handbook of Thin Film Technology, McGraw-Hill.
3. Hari Singh Nalwa, Handbook of Thin Film Materials, Academic Press.
4. R.F. Bunshah, Handbook of Deposition Technologies for Films and Coatings, William Andrew Publishing.
5. Sam Zhang, Surface Engineering: Enhancing Life of Tribological Components, CRC Press.

Web links and Video Lectures (e-Resources):

1. https://ocw.mit.edu?utm_source
2. https://nanohub.org?utm_source
3. https://www.asminternational.org?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 thin film growth mechanisms, surface phenomena, and interface engineering concepts.
2. Analyze advanced deposition techniques and process parameters for fabricating high-quality thin films.
3. Apply surface engineering and modification methods to enhance material performance and

functionality.

4. Evaluate structural, chemical, mechanical, optical, and electrical properties of thin films using advanced characterization techniques.
5. Develop thin-film and surface-engineered solutions for applications in electronics, energy systems, biomedical devices, and protective coatings.

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

Nanocomposites & Smart Materials			
Course Code	**1MNT106B**	Scheme	2026
Type of Course	Professional Elective Courses-II (PEC)	Semester	1
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. Introduce students to advanced functional materials including photonic, spintronic, plasmonic, magnetic, and smart materials used in emerging technologies.
2. Develop an understanding of the structure–property relationships governing the behavior of nanostructured and multifunctional materials.
3. Explore the principles of light-matter interaction, spin-dependent phenomena, plasmonic effects, and smart material responses for technological applications.
4. Familiarize students with recent advances in nanotechnology-enabled materials for sensing, imaging, communication, energy, and biomedical applications.
5. Enable students to evaluate and select appropriate advanced materials for next-generation electronic, photonic, and intelligent systems.

Module-1

Photonic Materials: Need forNew 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.

Number of Hours: 09

Module-2

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

Number of Hours: 09

Module-3

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

Number of Hours:08

Module-4

Smart Materials

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

Number of Hours:08

Module-5

Magneticmaterials,

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

Number of Hours:08

Textbooks:

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.

Reference books / Manuals:

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

Web links and Video Lectures (e-Resources):

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

Assessment Structure (both CIE and SEE)

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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 fundamentals of photonic materials, nanophotonics, nonlinear optics, and their applications in advanced imaging and communication systems.
2. Analyze the properties and applications of spintronic materials, dilute magnetic semiconductors, and wide bandgap semiconductor materials.
3. Evaluate plasmonic nanostructures, local field enhancement mechanisms, and their applications in waveguiding, sensing, and optoelectronic devices.
4. Classify smart materials based on their response mechanisms and assess their suitability for sensors, actuators, and adaptive systems.

5. Examine magnetic nanomaterials, ferrofluids, shape memory materials, and biomimetic materials for advanced engineering applications.

Mappingof COSandPOs

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

Nanotoxicology & Environmental Nanotechnology			
Course Code	1MNT106C	Scheme	2026
Type of Course	Professional Elective Courses-II (PEC)	Semester	1
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 role of nanotechnology in addressing environmental challenges and promoting sustainable development.
2. Analyze the environmental fate, transport, and risk assessment of engineered nanomaterials.
3. Evaluate nanotechnology-based approaches for water purification, air pollution control, and waste management.
4. Investigate nanomaterial-enabled technologies for sustainable energy production and storage.
5. Assess the environmental, ethical, regulatory, and societal implications of nanotechnology applications.

Module-1

Introduction to Nanotechnology and Environment : Introduction to nanotechnology and its applications in environmental science and engineering, Properties of nanoparticles and their relevance to environmental applications, Current status and future prospects of nanotechnology in environmental science and engineering, Safety and ethical issues associated with the use of nanotechnology in the environment, Role of nanotechnology in addressing environmental challenges, including pollution, climate change, and energy security; Nanotechnology-based solutions for water and air pollution control, sustainable energy production, and waste management, Regulatory aspects of nanotechnology in the environment, Emerging trends and challenges in nanotechnology and environment

Number of Hours: 09

Module-2

Nanoparticles and Environmental Fate :

Fate and transport of nanoparticles in the environment; Behavior of nanoparticles in different environmental matrices (air, water, soil, and sediments); Factors affecting the fate and transport of nanoparticles, including particle size, surface charge, and coating; Environmental risks associated with the use of nanoparticles; Methods for measuring and monitoring nanoparticles in the environment; Environmental risk assessment and management of nanoparticles; Life cycle assessment of nanoparticles in environmental applications; Case studies of nanoparticle impact on the environment and human health.

Number of Hours: 09

Module-3

Nanotechnology for Water Treatment :

Overview of water treatment technologies; Role of nanotechnology in water treatment and purification; Nanoparticle-based adsorption and membrane filtration processes; Nanoparticle-based sensors for water quality monitoring; Nanotechnology-based approaches for desalination and water reuse; Nanoparticle-based disinfection and sterilization of water; Treatment of emerging contaminants using nanotechnology; Economic and environmental aspects of

nanotechnology-
based water treatment systems.

Number of Hours:08

Module-4

Nanotechnology for Air Pollution Control Overview of air pollution and its sources; Role of nanotechnology in air pollution control and remediation; Nanoparticle-based catalysts for the removal of air pollutants; Nanoparticle-based adsorption and filtration processes for air purification; Nanoparticle-based sensors for air quality monitoring; Nanotechnology-based approaches for carbon capture and storage; Life cycle assessment of nanotechnology-based air pollution control systems; Case studies of successful applications of nanotechnology in air pollution control.

Number of Hours:08

Module-5

Nanotechnology for Sustainable Energy: Overview of energy systems and their environmental impact; Role of nanotechnology in sustainable energy production and storage; Nanoparticle-based solar energy conversion systems; Nanoparticle-based hydrogen production and storage systems; Nanotechnology-based approaches for fuel cells and batteries; Nanotechnology-based approaches for carbon capture and storage; Life
cycle assessment of nanotechnology-based energy systems; Case studies of successful applications of nanotechnology in sustainable energy production and storage

Number of Hours:08

Textbooks:

1. Mark R. Wiesner and Jean-Yves Bottero, Environmental Nanotechnology: Applications and Impacts of Nanomaterials, McGraw-Hill.
2. Mahendra Rai and Nelson Duran, Environmental Applications of Nanotechnology, CRC Press.
3. Jo Anne Shatkin, Nanotechnology: Health and Environmental Risks, CRC Press.

Reference books / Manuals:

1. C.N.R. Rao and A. Muller, The Chemistry of Nanomaterials, Wiley-VCH.
2. T. Pradeep, A Textbook of Nanoscience and Nanotechnology, McGraw-Hill.
3. Bharat Bhushan, Springer Handbook of Nanotechnology, Springer.

Web links and Video Lectures (e-Resources):

1. Introduction to Nanotechnology by the NationalNanotechnologyInitiative - https://www.youtube.com/watch?v=Kj9XmCOY-Ko
2. The Impact of Nanotechnology on Environmental Sustainability by Cambridge University
3. https://www.youtube.com/watch?v=rQ2V7Z01jK0
4. Fate and Transport of Nanoparticles in the Environment by the Center for Sustainable Nanotechnology - https://www.youtube.com/watch?v=Zl-dI6rBfQc

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 environmental nanotechnology and the role of nanomaterials in pollution control, resource conservation, and sustainability.
2. Analyze the behaviour, transport mechanisms, environmental fate, and ecological impacts of nanoparticles in various environmental systems.
3. Evaluate nanotechnology-based solutions for water treatment, contaminant removal, and environmental monitoring.
4. Assess the effectiveness of nanomaterial-based technologies for air pollution control and sustainable energy applications.
5. Develop environmentally responsible strategies by considering risk assessment, life-cycle analysis, regulatory frameworks, and sustainability aspects of nanotechnology.

Mappingof COSandPOs

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

Nano pharmaceuticals & Drug Delivery Systems			
Course Code	**1MNT106D**	Scheme	2026
Type of Course	Professional Elective Courses-II (PEC)	Semester	1
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 principles, design strategies, and mechanisms of conventional and nanotechnology-based drug delivery systems.
2. Explore various nanoscale drug carriers and evaluate their suitability for targeted and controlled drug delivery applications.
3. Analyze the role of nanotechnology in drug discovery, cancer therapy, and advanced therapeutic interventions.
4. Examine the applications of nanomedicines in diagnostics, treatment, and regenerative medicine.
5. Familiarize students with nanoanalytical tools and nanoparticle-based labeling techniques used in biomedical research and healthcare.

Module-1

Principles of drug delivery systems (DDS)

Design of drug delivery systems, Aims of DDS, Modes of drug delivery, ADME hypothesis – controlled drug delivery, site specific drugs , barriers for drug targeting, passive and active targeting, Strategies for site specific, time and rate controlleddelivery ofdrugs, antibodybased and metabolism-based targeting.

Number of Hours: 09

Module-2

Nano sized Drug Carriers

Structure and Preparation- Liposomes, Cubosomes and Hexosomes, Solid Lipid Nanoparticles (SLP). Lipid based colloidal system, Liposomal Drug Carriers, Dendrimer (PAMAM), Polymer Micelle, Ceramic and Magnetic nanoparticle, Polymer drug conjugates. Nanotubes, Nanowires, Nanocage, Nanorods, Nanofibers, and Fullerenes, Carbon nanotubes biocompatibility. Smart drug delivery systems, Multifunctional Drug carriers, organic and inorganic composites. Problems with DDS, Drug loading efficiency in nanovehicles, complexity of Nanocarriers, interface between synthetic materials and biological tissues or components, safety and ethical issues, Nanotechnology for future DDS.

Number of Hours: 09

Module-3

Drug Discovery & Cancer therapy

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 forbrain tumortherapy, Targeting through angiogenesis and Folate Receptors Liposomal formulation in cancer therapy, application of liposomes in pharmaceutical and cosmetic applications.

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 Nanomechanics, Molecular devices, Nanomedicines for Skin disorders, wound healing, eye diseases, infections, Nanotubes for detection and destruction of bacteria.

Number of Hours:08

Module-5

Nanoanalytics

Nanoparticles for biological labelling, Nano-Imaging Agents, Nano particles molecular labels, Immunogold-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 targeted to His Tabs, gold cluster nanoscrystals.

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

Web links and Video Lectures (e-Resources):

1. Introduction to Nanotechnology by the National Nanotechnology
2. Initiative - https://www.youtube.com/watch?v=Kj9XmCOY-Ko
3. The Impact of Nanotechnology on Environmental Sustainability by Cambridge University
4. https://www.youtube.com/watch?v=rQ2V7Z01jK0

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 drug delivery systems, targeting mechanisms, and controlled drug release strategies.
2. Analyze the structure, properties, and applications of various nanoscale drug carriers for therapeutic delivery.
3. Evaluate the role of nanotechnology in drug discovery, cancer therapy, and advanced pharmaceutical applications.
4. Assess the applications of nanomedicines in diagnostics, disease treatment, and healthcare technologies.
5. Examine nanoanalytical techniques and nanoparticle-based labeling methods for biomedical and bioimaging applications.

Mappingof COSandPOs

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

Nanomaterials Synthesis and Characterisation lab			
Course Code	1MNTL107A	Scheme	2026
Type of course	Professional Core Course Lab	Semester	1
Teaching Hours/Week (L:T:P)	0:0:3	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	0: 0:28:02	SEE Marks	50
Credits	01	Total Marks	100
Type of Examination	Practical	Exam Hours	03

Course outcome (Course Skill Set)

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

1. To synthesize nanomaterials using various chemical and physical methods.
2. To characterize nanomaterials using advanced analytical techniques.
3. To correlate synthesis parameters with material properties.
4. To develop skills in experimental design, data analysis, and interpretation.
5. To provide exposure to research-oriented problem-solving in nanotechnology.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
   a. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **80 marks** out of the maximum 100 marks.
   b. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **20 marks.**

For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills.

PART – A
List of experiments

1. Synthesis of ZnO Nanoparticles by Sol-Gel Method
2. Synthesis of Silver Nanoparticles by Chemical Reduction Method
3. Synthesis of TiO_2 Nanoparticles by Solvothermal Technique
4. Synthesis of Iron Oxide (Fe_3O_4) Magnetic Nanoparticles by Co-precipitation Method
5. Determination of absorption peak and optical band gap through UV Visible spectroscopy
6. Estimation of particle size and morphology using Scanning Electron Microscopy (SEM)
7. Structural & Phase purity Characterization of given nanomaterials Using X-Ray Diffraction (XRD)

PART – B
OPEN ENDED EXPERIMENTS

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

1. Optimization of Synthesis Parameters pH, precursor concentration, or annealing temperature on particle size for ZnO Nanoparticles
2. Compare nanoparticles synthesized using two different methods and evaluate their properties
3. Analyze degradation efficiency of Organic Dyes under different conditions Using Nanomaterials
4. Design and Development of a Nanomaterial-Based Water Treatment System
5. Fabrication and Evaluation of TiO2 NP's Thin Films using spray pyrolysis
6. Development of Nanomaterial-Based gas, humidity, or biosensor Prototype

Textbooks:

1. N. R. Rao, A. Müller and A. K. Cheetham, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Wiley-VCH, 2004.
2. Guozhong Cao and Ying Wang, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, 2nd Edition, World Scientific Publishing, 2011.
3. Dupas, P. Houdy and M. Lahmani, Nanoscience: Nanotechnologies and Nanophysics, Springer, 2007.

Reference books / Manuals:

1. Bharat Bhushan (Ed.), Springer Handbook of Nanotechnology, 4th Edition, Springer, 2017.
2. Charles P. Poole Jr. and Frank J. Owens, Introduction to Nanotechnology, Wiley India, 2009.
3. Dieter Vollath, Nanomaterials: An Introduction to Synthesis, Properties and Applications, 3rd Edition, Wiley-VCH, 2013.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/@nptelhrd
2. https://www.nano.gov

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 a pass in the course.

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 (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. Synthesize nanomaterials using suitable chemical and physical techniques.
2. Characterize nanomaterials using analytical tools such as UV-Vis, XRD, SEM, and EDX.
3. Analyze the relationship between synthesis conditions and nanomaterial properties.
4. Design and conduct open-ended experiments for nanotechnology applications.
5. Interpet experimental results and communicate technical findings effectively.

C-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

Nanoelectronics & Device Fabrication Lab			
Course Code	**1MNTL107B**	Scheme	2026
Type of course	Professional Core Course Lab	Semester	1
Teaching Hours/Week (L:T:P)	0:0:3	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	0: 0:28:02	SEE Marks	50
Credits	01	Total Marks	100
Type of Examination	Practical	Exam Hours	03

Course outcome (Course Skill Set)

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

1. To synthesize nanomaterials using various chemical and physical methods.
2. To characterize nanomaterials using advanced analytical techniques.
3. To correlate synthesis parameters with material properties.
4. To develop skills in experimental design, data analysis, and interpretation.
5. To provide exposure to research-oriented problem-solving in nanotechnology.

Note:

4. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
5. Both PART-A and PART-B are considered for CIE and SEE.
6. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
   c. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **80 marks** out of the maximum 100 marks.
   d. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **20 marks.**

For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills.

PART – A
List of experiments

1. Fabrication of ZnO thin films by spin coating and determination of film thickness and optical bandgap.
2. Synthesis of conductive PEDOT:PSS thin films and measurement of sheet resistance using the four-point probe method.
3. Preparation of Ag nanoparticle-coated conductive films and evaluation of electrical conductivity.
4. Measurement of I–V characteristics of a p–n junction diode and extraction of diode parameters.
5. Characterization of MOS capacitor structures through capacitance-voltage (C–V) measurements.
6. Determination of resistivity and carrier concentration of semiconductor samples using

Hall Effect measurements.

7. Characterization of thin-film surface morphology using Atomic Force Microscopy (AFM) data.

PART – B
OPEN ENDED EXPERIMENTS

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

1. Optimize spin-coating parameters to achieve minimum sheet resistance in ZnO thin films.
2. Design and evaluate a humidity sensor based on nanostructured metal oxide thin films.
3. Investigate the effect of annealing temperature on the electrical properties of conductive thin films.
4. Develop a nanocomposite conductive film and compare its conductivity with pristine films.
5. Model and simulate a nanoscale MOSFET using COMSOL Multiphysics and analyze scaling effects.
6. Design a gas sensor using metal oxide nanomaterials and evaluate sensitivity under different operating conditions.
7. Study the influence of nanoparticle concentration on the performance of a flexible electronic device.

Textbooks:

1. S. M. Sze and Kwok K. Ng, Physics of Semiconductor Devices, 3rd Edition, Wiley, 2007.
2. Jaeger Richard C., Introduction to Microelectronic Fabrication, 2nd Edition, Pearson Education.
3. Sorab K. Ghandhi, VLSI Fabrication Principles: Silicon and Gallium Arsenide, Wiley India.

Reference books / Manuals:

1. Marc J. Madou, Fundamentals of Microfabrication and Nanotechnology, 3rd Edition, CRC Press.
2. Stephen A. Campbell, Fabrication Engineering at the Micro and Nanoscale, Oxford University Press.
3. Robert F. Pierret, Semiconductor Device Fundamentals, Pearson Education.

Web links and Video Lectures (e-Resources):

1. https://ocw.mit.edu/
2. https://www.comsol.com/support/learning-center

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 a pass in the course.

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 (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. Apply thin-film deposition, lithography, and etching techniques for nanoelectronic device fabrication.
2. Characterize electrical and physical properties of nanoelectronic materials and devices.
3. Analyze the performance of semiconductor and nanoelectronic devices using experimental and simulation methods.
4. Design and conduct open-ended experiments related to nanoelectronics and device fabrication.
5. Interpret experimental results and communicate technical findings effectively.

C-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

Energy Nanomaterials & Electrochemical Characterisation Lab			
Course Code	**1MNTL107C**	Scheme	2026
Type of course	Professional Core Course Lab	Semester	1
Teaching Hours/Week (L:T:P)	0:0:3	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	0: 0:28:02	SEE Marks	50
Credits	01	Total Marks	100
Type of Examination	Practical	Exam Hours	03

Course outcome (Course Skill Set)

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

1. To provide hands-on experience in electrochemical techniques used for material and device characterization.
2. To understand charge transfer mechanisms, electrode kinetics, and electrochemical processes.
3. To evaluate the electrochemical performance of energy storage and conversion materials.
4. To develop skills in data acquisition, analysis, and interpretation of electrochemical measurements.
5. To expose students to research-oriented applications in batteries, supercapacitors, corrosion, and sensors.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
4. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **80 marks** out of the maximum 100 marks.
5. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **20 marks.**

For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills.

PART – A
List of experiments

6. Determination of ionic conductivity of electrolyte materials using Electrochemical Impedance Spectroscopy (EIS).
7. Measurement of cyclic voltammetry (CV) characteristics of a ferri/ferrocyanide redox system.
8. Evaluation of charge transfer resistance and equivalent circuit parameters using EIS analysis.
9. Determination of specific capacitance of activated carbon electrodes using cyclic voltammetry.
10. Measurement of galvanostatic charge-discharge characteristics of supercapacitor electrodes.
11. Investigation of corrosion behavior of metallic samples using Tafel polarization studies.
12. Determination of electrochemical stability window of electrolyte systems using linear

sweep voltammetry.

13. Evaluation of battery electrode performance using charge-discharge cycling data.

PART – B

OPEN ENDED EXPERIMENTS

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

1. Optimize electrode composition to maximize the specific capacitance of a supercapacitor electrode.
2. Investigate the influence of scan rate on the electrochemical behavior of nanostructured electrodes.
3. Analyze the effect of electrolyte concentration on ionic conductivity and impedance characteristics.
4. Design and evaluate a symmetric or asymmetric supercapacitor using available electrode materials.
5. Study the influence of nanomaterial loading on battery electrode performance.
6. Develop an equivalent circuit model for an electrochemical system and validate it using EIS data.
7. Investigate degradation mechanisms of an electrode through repeated charge-discharge cycling.
8. Compare the electrochemical performance of two nanostructured electrode materials for energy storage applications.

Textbooks:

1. S. M. Sze and Kwok K. Ng, Physics of Semiconductor Devices, 3rd Edition, Wiley, 2007.
2. Jaeger Richard C., Introduction to Microelectronic Fabrication, 2nd Edition, Pearson Education.
3. Sorab K. Ghandhi, VLSI Fabrication Principles: Silicon and Gallium Arsenide, Wiley India.

Reference books / Manuals:

1. Marc J. Madou, Fundamentals of Microfabrication and Nanotechnology, 3rd Edition, CRC Press.
2. Stephen A. Campbell, Fabrication Engineering at the Micro and Nanoscale, Oxford University Press.
3. Robert F. Pierret, Semiconductor Device Fundamentals, Pearson Education.

Web links and Video Lectures (e-Resources):

1. https://ocw.mit.edu/
2. https://www.comsol.com/support/learning-center

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 a pass in the course.

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 (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. Perform electrochemical measurements using CV, EIS, polarization, and charge-discharge techniques.
2. Analyse electrochemical behaviour and charge transfer mechanisms in materials and devices.
3. Evaluate the performance of batteries, supercapacitors, and electrochemical systems using experimental data.
4. Design and conduct open-ended investigations related to electrochemical characterization.
5. Interpret electrochemical data 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

Nanobiotechnology & Biosensors Lab			
Course Code	**1MNTL107D**	Scheme	2026
Type of course	Professional Core Course Lab	Semester	1
Teaching Hours/Week (L:T:P)	0:0:3	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	0: 0:28:02	SEE Marks	50
Credits	01	Total Marks	100
Type of Examination	Practical	Exam Hours	03

Course outcome (Course Skill Set)

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

1. To provide practical exposure to nanobiotechnology techniques used in biological and biomedical applications.
2. To understand the synthesis, functionalization, and characterization of nanomaterials for biosensing applications.
3. To investigate biomolecule–nanomaterial interactions and their role in diagnostics.
4. To develop skills in biosensor fabrication, testing, and performance evaluation.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
4. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **80 marks** out of the maximum 100 marks.
5. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **20 marks.**

For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills.

PART – A
List of experiments

1. Synthesis of silver nanoparticles using a green synthesis route and characterization using UV-Visible spectroscopy.
2. Determination of protein concentration using UV-Visible spectrophotometric analysis.
3. Immobilization of glucose oxidase on nanostructured substrates for biosensing applications.
4. Evaluation of antibacterial activity of silver nanoparticles against selected bacterial strains.
5. Preparation and characterization of chitosan-based nanocomposite films for biomedical applications.
6. Measurement of sensitivity and response time of a glucose biosensor.
7. Characterization of nanoparticle size distribution using Dynamic Light Scattering (DLS) data.
8. Analysis of biomolecule–nanoparticle interactions through UV-Visible spectral studies.

PART – B
OPEN ENDED EXPERIMENTS

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

1. Optimize synthesis parameters to maximize the stability and yield of biologically synthesized nanoparticles.
2. Design and evaluate a colorimetric biosensor for the detection of glucose or urea.
3. Investigate the effect of nanoparticle concentration on antimicrobial efficiency.
4. Develop a nanocomposite-based biosensing platform for biomolecule detection.
5. Study the influence of enzyme immobilization conditions on biosensor performance.
6. Fabricate and evaluate a paper-based biosensor for rapid diagnostic applications.
7. Compare the sensing performance of metallic and metal oxide nanoparticles in biosensing applications.
8. Develop a biosensor prototype for environmental monitoring or healthcare diagnostics using nanomaterials.

Textbooks:

1. David Goodsell, Bionanotechnology: Lessons from Nature, Wiley-Liss.
2. Ehud Gazit, Plenty of Room for Biology at the Bottom: An Introduction to Bionanotechnology, Imperial College Press.
3. K. E. Geckeler and E. Rosenberg, Functional Nanomaterials for Medicine and the Environment, ACS Publications.

Reference books / Manuals:

1. Vladimir Torchilin, Nanoparticulates as Drug Carriers, Imperial College Press.
2. Lisa A. Nagahara and Ihab A. Hassan (Eds.), Nanobiotechnology Handbook, CRC Press.
3. G. K. Knopf and A. S. Bassi, Smart Biosensor Technology, CRC Press.

Web links and Video Lectures (e-Resources):

1. https://ocw.mit.edu
2. https://ocw.mit.edu/
3. https://www.comsol.com/support/learning-center

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 a pass in the course.

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 (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. Synthesize and characterize nanomaterials used in biological and biomedical applications.
2. Analyze interactions between nanomaterials and biological systems for diagnostic and therapeutic applications.
3. Fabricate and evaluate biosensors using nanomaterials and biomolecules.
4. Design and conduct open-ended investigations related to nanobiotechnology and biosensing.
5. Interpret experimental 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

Thin Film Deposition Lab			
Course Code	**1MNTL107E**	Scheme	2026
Type of course	Professional Core Course Lab	Semester	1
Teaching Hours/Week (L:T:P)	0:0:3	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	0: 0:28:02	SEE Marks	50
Credits	01	Total Marks	100
Type of Examination	Practical	Exam Hours	03

Course Objectives

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

1. To provide practical knowledge of thin-film deposition techniques and processing parameters.
2. To understand the influence of deposition conditions on thin-film properties.
3. To characterize structural, optical, electrical, and surface properties of thin films.
4. To develop skills in thin-film fabrication for electronic, optoelectronic, and energy applications.
5. To enable students to design and optimize thin-film-based devices through experimental investigations

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
4. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **80 marks** out of the maximum 100 marks.
5. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **20 marks.**

For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills.

PART – A

List of experiments

1. Deposition of ZnO thin films by spin coating and evaluation of film thickness and optical transmittance.
2. Deposition of TiO_2 thin films using the sol-gel spin coating technique and determination of optical bandgap.
3. Fabrication of conductive PEDOT:PSS thin films and measurement of sheet resistance using the four-point probe method.
4. Deposition of silver thin films by thermal evaporation and characterization of electrical conductivity.
5. Investigation of the effect of annealing temperature on the crystallinity of ZnO thin films using XRD analysis.
6. Measurement of surface roughness and morphology of deposited thin films using AFM/SEM data.
7. Determination of optical constants of thin films using UV-Visible spectroscopy.
8. Evaluation of adhesion and thickness uniformity of deposited thin films using profilometry data.

PART – B
OPEN ENDED EXPERIMENTS

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

1. Optimize spin-coating parameters to obtain minimum surface roughness and maximum thickness uniformity in ZnO thin films.
2. Investigate the effect of precursor concentration on the structural and optical properties of TiO_2 thin films.
3. Develop a transparent conducting thin film and evaluate its figure of merit for optoelectronic applications.
4. Study the influence of annealing atmosphere on the electrical properties of metal oxide thin films.
5. Fabricate a multilayer thin-film structure and analyze the effect of layer thickness on optical transmission.
6. Compare the properties of thin films deposited using spin coating and dip coating techniques.
7. Design a thin-film-based humidity or gas sensor and evaluate its sensing performance.
8. Model the optical behavior of a thin-film stack using COMSOL/MATLAB and validate the results experimentally.

Textbooks:

1. Donald L. Smith, Thin-Film Deposition: Principles and Practice, McGraw-Hill.
2. Milton Ohring, Materials Science of Thin Films, 3rd Edition, Academic Press.
3. Leonard I. Maissel and Reinhard Glang, Handbook of Thin Film Technology, McGraw-Hill.

Reference books / Manuals:

1. Krishna Seshan and D. Schepis, Handbook of Thin Film Deposition, 4th Edition, Elsevier.
2. Hari Singh Nalwa, Handbook of Thin Film Materials, Academic Press.
3. O. S. Heavens, Optical Properties of Thin Solid Films, Dover Publications.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/127105531?utm_source
2. https://onlinecourses.nptel.ac.in/noc24_ge56/preview?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 a pass in the course.

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.