Gyanmanjari Innovative University

Course Syllabus.
Gyanmanjari Institute of Technology
Semester-1 (M.Tech)

Subject: Application of Nanotechnology in Chemical Engineering -METCH11505

Type of course: Minor Stream

Prerequisite: None

Rationale: The purpose of this course is to introduce students with the concepts of nano science and nanotechnology in the design and development of systems and technologies that utilize the special qualities of nano scale materials to create entirely new capacities and functionality. It would also concentrate on the fundamental scientific, technological, and engineering challenges for developing nanotechnology in the controlled synthesis of nanostructured materials, particularly for technologies that are significant for industry, energy, and the environment. The curriculum was created to satisfy this new engineering discipline's educational requirements.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks					Total Marks
				Theory Marks		Practical Marks		CA	
CI	T	P	C	ESE	MSE	V	P	ALA	
4	0	2	5	60	30	10	20	30	150

Legends: CI-Classroom Instructions; T – Tutorial; P - Practical; C – Credit; ESE – End Semester Examination; MSE- Mid Semester Examination; CA - Continuous Assessment; ALA-Active Learning Activities.

Course Content:

Sr. No	Course content	Hrs	% Weightage
1	**Introduction:** Definition of nanomaterial, nanoscience, nanotechnology; History and scope of nanomaterials; Emergence of nanotechnology and Moore's law; Classification of nanomaterials; Nano dimension impact on (i) elastic properties, (ii) melting point, (iii) diffusivity, (iv) Grain growth characteristics, (v) solid solubility, (vi) Magnetic, (vii) electrical, (viii) optical, (ix) mechanical and, (x) thermal properties. Physical chemistry concept of nanomaterials: (i) surface energy, (ii) Chemical potential, (iii) Electrostatic Stabilization, and (iv) Steric Stabilization.	12	20
2	**Nanomaterial synthesis using Top-down approach:** Mechanical alloying, Equal channel angular pressing, High-pressure torsion, Accumulative roll bonding, Nanolithography **Nanomaterial synthesis using Bottom-up approach:** Physical vapour deposition, Chemical vapour deposition, Magnetron sputtering,molecular beam epitaxy,Colloidal methods,Spray conversion processing, Sol–gel process, Electrodeposition, Hydrothermal and solvothermal method, Wet chemical synthesis, Self-assembly.	12	20
3	**Synthesis of nanoparticles:** Homogeneous nucleation, Heterogeneous nucleation, Factor affecting size of nanoparticles, Conventional methods, Novel methods such as sonochemical and microwave. Synthesis methods of 1D, 2D nanomaterials, Nanostructure fabrication by physical techniques.	12	20

4	**Characterization of nanomaterials:** X-Ray Diffraction (XRD), Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy, UV/Visible Spectroscopy, Scanning Tunnelling Microscopy, Filed Ion Microscopy, Three dimensional atom probe, Nano indentation. **Synthesis route of Nanostructured Materials with High Application Potential:** (i) Quantum dot, (ii) carbon nanotube, (iii) GaN nanowires, (iv) Nano crystalline ZnO, (v) Nano-crystalline TiO2, (vi) Titania nanotubes, (vii) M50 steel, (viii) Silicon based nanostructure, (ix) Fullerene, and (x) micro and mesoporous materials.	12	20
5	**Applications of nanomaterials:** (i) Cosmetics and Consumer Goods, (ii) Nano Sensor, (iii) Nano catalysts, (iv) Water Treatment and the Environment, (v) Paints, (vi) Food and Agriculture Industry, (vii) energy storage, (ix) Nano-medical Applications, and (x) Textiles **Scope, Concerns and Challenges of nanotechnology:** Scalability, Environmental, ecological and health hazards of nanoparticles, Nano-toxicology and its effect	12	20

Continuous Assessment:

Sr. No	Active Learning Activities	Marks
1	**Preparation of Multimedia Presentations on Nanotechnology Topics:** Students will prepare PowerPoint presentations including videos, animations, pictures, and graphics to enhance understanding of key theoretical concepts such as nanomaterial classification, synthesis, and characterization techniques. Faculty will assign specific units or subtopics to student groups so that the entire syllabus is effectively covered. Presentations will be delivered in class and the final files submitted on the GMIU Web Portal.	10
2	**Characterization of Nanomaterials – Case Study:** Each student/group will prepare a case study report demonstrating the use of techniques like XRD, SEM, TEM, or UV–Vis spectroscopy in nanomaterial characterization. The report should include sample data interpretation and a comparative analysis of at least two techniques. The final report will be submitted through the GMIU Web Portal.	10

3	**Nanomaterial Synthesis Demonstration (Virtual or Laboratory-Based):** Students will perform or simulate the synthesis of nanoparticles or nanomaterials using one of the studied methods (e.g., sol-gel, hydrothermal, or precipitation). They will document the synthesis steps, parameters, and safety precautions, and prepare a short video or illustrated report for submission on the GMIU Web Portal.	10
Total		30

Suggested Specification table with Marks (Theory): 60

Distribution of Theory Marks (Revised Bloom's Taxonomy)						
Level	Remembrance (R)	Understanding (U)	Application (A)	Analyze (N)	Evaluate (E)	Create (C)
Weightage	12%	35%	07%	09%	07%	00%

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Course Outcome:

After learning the course, the students should be able to:	
CO1	To understand and classify nanomaterials and impact of nano size on nanomaterials property.
CO2	To gain the knowledge of nanomaterial synthesis by different methods and its approach.
CO3	To understand the characterization of nanomaterials by various techniques.
CO4	To study the scope and applications of nanotechnology in chemical industry as well as its environmental impact.

List of Suggested Practical

Sr. No	Suggested Practical
1	Preparation of catalyst by wet impregnation method.
2	Preparation of catalyst by precipitation method.
3	Preparation of catalyst by co-precipitation method.
4	Preparation of catalyst by hydrothermal method.
5	To synthesize a heterogeneous catalyst by sol-gel method.
6	To synthesize graphene oxide nanomaterials.
7	Synthesis of nanoparticles
8	Effect of process conditions of size and shape of nanoparticles.
9	To identify the functional group and analyze the sample using FTIR.
10	To analyze the sample using UV-vis spectroscopy.

Instructional Method:

The course delivery method will depend upon the requirement of content and the needs of students. The teacher, in addition to conventional teaching methods by black board, may also use any tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.

From the content 10% topics are suggested for flipped mode instruction. Students will use supplementary resources such as online videos, NPTEL/SWAYAM videos, e-courses. The internal evaluation will be done on the basis of Active Learning Assignment.

Practical/Viva examination will be conducted at the end of semester for evaluation of performance of students in the laboratory.

Reference Books:

[1] Textbook of Nanoscience and Nanotechnology, B.S. Muty, P. Shankar, Baldev Raj, B.B Rath and James Murday, University Press, IIM (ISBN-978 81 7371 738 3).

[2]. Nanostructures and Nanomaterials: Synthesis, Properties and Applications by G. Cao, Imperial College Press, 2004.

[3]. The Chemistry of Nanomaterials: Synthesis, Properties and Applications by C. N. R. Rao, A. Muller, A. K. Cheetham, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, ISBN: 3-527-30686-2.

[4]. Nanomaterials: Synthesis, Properties & Applications, by Edelstein, A. S & R C Cammarata (Eds.), Taylor & Francis, New York, 1996.

[5]. Introduction to Nanotechnology, C.P. Poole Jr. and F.J.Owens, Wiley, 2003.

[6]. Hand book of Nanostructured Materials and Nanotechnology, H. Nalwa, Vol. 1 to 5, Academic Press, 1999. 7. Hand book of Nanotechnology, B. Bhusan, Springer, 2004.