



FIRST SEMESTER 2020-21
COURSE HANDOUT

Date: 11.03.2021

In addition to the part I (General Handout for all courses appended to the Time table) this portion gives further specific details regarding the course.

Course No : CHE G528
Course Title : Introduction to Nano Science and Technology
Instructor-in-Charge : Krishna Etika
Instructor(s) : Banasri Roy
Practical/Project Instructors: Krishna Etika and Banasri Roy

1. Course Description:

Nanotechnology promises to be the technology of the future benefitting humanity in a number of ways. This course is aimed at preparing students for further industrial or academic work in the field of nanotechnology. The objective of this course is to introduce the basic concepts of nanomaterials science and technology with special emphasis on synthesis, characterization, and applications of nanomaterials in various fields such as electronics, medical, MEMS, photonics, catalysis, energy, and heat transfer. This course will also deal with the quantum mechanical aspects of nanomaterials. Furthermore, future directions in nanoscience and technology and large scale manufacture and technological issues will also be discussed.

2. Scope and Objective of the Course:

The course content has been structured to provide a well-rounded overview of the principles of nanoscience and nanotechnology. The course will include common synthesis methods for the nanoparticles, their characterization and will also discuss the unique properties of nanomaterials, which makes them an attractive material for many applications. Laboratory demonstrations will include nanoparticles synthesis and characterization experiments. Emphasis is laid on demonstrating the motivation and use of nanomaterials in a variety of applications. This course is aptly suited for any student looking to get hands-on training in the widely prevalent field of nanoscience and nanotechnology.

3. Text Books:

- TB-1: William A. Goddard, III, Donald W. Brenner, Sergey E. Lyshevski and Gerald J. Iafrate, " Handbook of Nanoscience, Engineering and Technology", CRC Press, ed 3 (March 12, 2012) ISBN-13: 978-1-4398-6016-8.
- TB-2: Risal Singh and Shipra Mital Gupta, "Introduction to Nanotechnology", Oxford University Press, ed 1 (2016). ISBN-13:978-0-19-945678-9
- TB-3: James Murday, B S Murty, P Shankar, Baldev Raj, and BB Rath, "Textbook of Nanoscience and Nanotechnology" University Press – IIM; ed 1 (2012) ISBN: 978-81-7371-738-3.

4. Reference Books:

1. Bharat Bhushan, "Handbook of Nanotechnology", Springer, Germany, 2nd ed., 2006, ISBN 13: 9783540298557
2. Hari Singh Nalwa, "Handbook of Nanostructured Materials and Nanotechnology", Academic Press, 2001, ISBN 13: 9780080533643.



BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, Pilani
Pilani Campus
AUGS/ AGSR Division

3. Paul Harrison, "Quantum Wells, Wires & Dots, Theoretical & Computational Physics of Semiconductors Nanostructures", John Wiley & Sons, Ltd, 2nd ed., 2006, ISBN 13: 9780470010792.
4. Charles P Poole & Frank J. Ownes, "Introduction to Nanotechnology", Wiley-Interscience; 1st ed., ISBN-13: 978-0471079354
5. T. Pradeep, "A textbook of Nanoscience & Nanotechnology," McGraw Hill India, 1st ed., 2015, ISBN 13: 9781259007323.

6. Course Plan:

Module No/ Module Name	Topics to be covered	Learning Outcomes	Chapter in book
1 Introduction	Course introduction, what is nanoscience and nanotechnology? Difference between micro and nano, classification of nanostructured materials, unique properties of nanomaterials: structural, electronic, magnetic, optical, mechanical.	<ul style="list-style-type: none"> Elaborate the difference between nano and microscale List out the key properties of nanomaterials. 	TB-1+TB-2+ TB-3 + Notes in class
2 Nanomaterials Synthesis Techniques: Bottom-up	Bottom-up: physical vapor deposition (PVD), chemical vapor deposition (CVD), sol-gel, spray conversion, wet chemical synthesis, self-assembly	<ul style="list-style-type: none"> Discuss various bottom-up techniques for nanomaterials synthesis 	TB-1+TB-2+ TB-3 + Notes in class
3 Nanomaterials Synthesis Techniques: Top-down	Top-Down: Mechanical alloying, equal channel angular pressing, high-pressure torsion (HPT), accumulative roll bonding (ARB), Nanolithography	<ul style="list-style-type: none"> Discuss various top-down approaches for nanomaterials synthesis 	TB-1+TB-2+ TB-3 + Notes in class
4 Nanomaterials Characterization Techniques	Techniques used for characterization of nanomaterials: x-ray diffraction (XRD), small-angle x-ray scattering (SAXS), scanning electron microscopy (SEM), Transmission electron microscopy (TEM), atomic force microscopy (AFM), Scanning tunneling microscope (STM), Field Ion microscope (FIM), 3-D atom probe (3DAP), Nanoindentation.	<ul style="list-style-type: none"> Describe the basics of various characterization techniques used for structure and property evaluation of nanomaterials. 	TB-1+TB-2+ TB-3 + Notes in class
5 Quantum Mechanical	Basics of quantum physics, wave mechanics, Schrodinger	<ul style="list-style-type: none"> Elaborate the basic physics behind quantum 	TB-2+ Notes in



BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, Pilani
Pilani Campus
AUGS/ AGSR Division

Aspects of Nanomaterials	wave equation, concepts of quantum well, wire and dots, tunneling, applications of quantum mechanics in nanotechnology.	effects exhibited by nanomaterials.	class
6 Carbon-based Nanostructures	Synthesis, properties, and applications of carbon nanostructures: fullerenes, carbon nanotubes (CNTs), graphene, nanodiamonds, and diamond-like carbon (DLC).	• Identify various nano-structured forms of carbon and their synthesis and unique properties.	TB-1+TB-2+ TB-3 + Notes in class
7 Nanotechnology Applications: Electronics	Applications of nanotechnology in electronics: Basics of semiconductor devices, MOSFETs, FinFETs	• Review and suggest nanotechnology applications in electronic devices	Discuss in class from research papers
8 Nanotechnology Applications: Medical	Application of nanotechnology in medical devices: Basics of bio-electronic devices, nanosensors, molecular imaging, targeted drug delivery applications.	• Review and suggest nanotechnology applications in medical devices	Discuss in class from research papers
9 Nanotechnology Applications: MEMS/NEMS	Application of nanotechnology in MEMS: Basics of MEMS/NEMS, fabrication techniques, working principles of accelerometers, and actuators.	• Review and suggest nanotechnology applications in MEMS devices	Discuss in class from research papers
10 Nanotechnology Applications: Energy	Basics of fuel cells and batteries, nanotechnology applications in fuel cells, energy storage devices.	• Review and suggest nanotechnology applications in energy storage.	Discuss in class from research papers
11 Nanotechnology Applications: Catalysis	Basics of catalysis, synthesis of metal and oxide active phases, nanoreactors.	• Review and suggest nanotechnology applications in catalysis	Discuss in class from research papers
12 Nanotechnology Applications: Heat Transfer	Nanofluids: Synthesis, characterization, and applications relevant to heat transfer. State of the art and future research directions.	• Review and suggest nanotechnology applications in heat transfer	Discuss in class from research papers
13 Nanotech hurdles and challenges	Large scale manufacture and technological issues	• Explain the hurdles and avenues for further research in the field of nanotechnology.	Discuss in class from research papers



BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, Pilani
Pilani Campus
AUGS/ AGSR Division

6. Evaluation Scheme:

Component	Duration	Weightage (%)	Date & Time	Nature of component (Close Book/ Open Book)
Quiz (Best 3 out of 4)	20 min	15		CB and/or OB
Mid-Sem	90 min	30		CB and/or OB
Project Work	-	20		OB
Comprehensive	120 min	35		CB and/or OB

7. Online/Chamber Consultations: Thursdays 3:00-4:00 P.M. or by request.

8. Notices: The notices will be displayed in Nalanda and/or sent to institute email id of the student.

9. Make-up Policy: Make-up will be granted for genuine cases only. Certificate from an authenticated doctor must accompany the make-up application (*only prescription or vouchers for medicines will not be sufficient*). Except for an emergency, for all other cases, prior permission of IC is compulsory.

10. Note (if any): *The lecture notes (if any) provided to the students registered in this course is for academic purpose only and is considered the intellectual property of BITS Pilani. Such materials should not be uploaded to any external websites/forums without the permission of the Instructor.*

Krishna C. Etika
Instructor-in-charge
CHE G528