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

SECOND SEMESTER 2020-21
COURSE HANDOUT

Date: 14.01.2021

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

Course No	**:**	**BITS F 429**
Course Title	**:**	**Nanotechnology for Renewable Energy and Environment**
Instructor-in-Charge	**:**	**Krishna Etika**
Instructor(s)	**:**	**Banasri Roy**

1. Course Description:

The course introduces the fundamentals of nanoscience and technology and its applications in the areas of renewable energy and environment. It includes concepts such as macro vs. nano, physics at the nanoscale and unique properties of nanomaterials that make them a viable alternative to conventional materials. This course also includes basic fabrication, characterization and working mechanisms of solar cells (i.e., organic, quantum dot and dye sensitized solar cells), Fuel cells, batteries and carbon nanotube based energy storage devices. Furthermore, aspects of nanotechnology applications in solar cells, nanoelectrodes, catalysts systems for fuel cells and batteries are also included. This course further introduces the environmental applications of nanotechnology in sustainability, ground water remediation, adsorbents, ecotoxicological and toxicity of nanomaterials, transport and fate of nanomaterials and societal implications of nanotechnology.

2. Scope and Objective of the Course:

Nanotechnology promises to be the technology of the future benefitting the humanity in a number of ways. This course is aimed at preparing students for further industrial or academic work in the field of nano technology with focus on renewable energy and environment sector. The course is divided into 3 modules as decribed below.

- **Module 1**: General introduction to principles of nanoscience and technology
- **Module 2**: Nanotechnology applications in renewable energy sector
- **Module 3**: Nanotechnology applications in environmental sector.

The specific topics covered under each module are listed in the course plan (refer section 5 of this handout).

By the end of this course, the student will be able to:

- Describe the importance of nanomaterials and the origin of their unique properties.
- Summarize the fabrication characterization and working of solar cells, fuel cells, batteries, and CNT based energy storage devices.
- List the merits and motivations for using nanomaterials in renewable energy and environment sector.
- Gauge the applicability of alternate nanomaterials for use in energy and environment sector.
- Define toxic effect of nanotechnology on environment, relative remediation and precautions.

3. Text Books (TB):

1. 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.
2. Javier García-Martínez, "Nanotechnology for the Energy Challenge," Wiley-VCH; ed 1 (March 22, 2010) ISBN-10: 3527324011.
3. Mark R Weisner & Jean-Yves Bottero, "Environmental nanotechnology; applications and impacts of nanomaterials", McGraw Hill, 2007, ISBN-10: 0071477500.

4. Reference Books (RB):

1. L. Theodore and R. Kunz, " Nanotechnology Environmental Implications and Solutions", Wiley-Interscience, 2005, ISBN-10: 0471699764.
2. Nanotechnology Applications for Clean Water, Edited by, N. Savage, M. Diallo, J. Duncan, A. Street, R. Sustich

5. Course Plan:

Module No.	Lecture Session	Reference	Learning outcomes
1: Intoduction to Nanoscience and Nanotechnology	**L 1**: Introduction to nanoscience and nanotechnology and classification of nanomaterials	**TB 1 + Notes in Class**	**By the end of the module, student will be able to** ○ Describe the importance of nano-materials and the origin of their unique properties. ○ List the techniques used for synthesizing nanomaterials. ○ Summarize the concepts of quantum confinement in nanostructured materials.
	L 2-3: Unique properties of nanomaterials structural, electronic, magnetic, optical, mechanical.		
	L 4-5: Techniques for nanomaterials synthesis		
	L 6: Quantum confinement and basics of Quantum wells, wires and dots.		
2: Nanotechnology in Energy Field	**L 7-11**: Fabrication, characterization working mechanism and nanotechnology applications of solar cells (i.e., organic, quantum dot and dye sensitized solar cells)	**TB 2 + Notes in Class**	**By the end of the module, student will be able to** ○ Summarize the fabrication characterization techniques and working principles of solar cells, fuel cells, batteries, and CNT based energy storage devices. ○ List the merits and motivations for using nanomaterials in renewable energy and environment sector ○ Solve elementary problems on cyclic voltametry, impedance spectroscopy.
	L 12-14: Fabrication, characterization working mechanism and nanotechnology applications in fuel cells.		
	L 15-17: Fabrication, characterization working mechanism and nano-technology applications in batteries.		

	L 18-20: Synthesis and properties of carbon nanotubes and their application in fabricating energy storage devices		
3: Nanotechnology in Environmental field	**L21- 22**: Introduction **L23- 24**: Environmental fate & transport of nanomaterials **L25-30**: Nanomaterials for water remediation: reactivity, fate & lifetime, Delivery & transport issues. Nanomaterials as adsorbents: Adsorption at oxide nanoparticles, Solution interface, Nano materials adsorbent for water and waste water treatment. **L31-35**: Nanomaterials for air pollution and solid waste remediation **L36-40**: Toxicity of nanomaterials, Ecotoxicological impacts of nanomaterials, Paradigms in nanomaterial toxicity. Provide awareness about the social economic impact of nanotechnology and to handle the techniques effectively, enhance the nanotechnology research by taking ethics and public opinion into consideration	**TB 3 +Journal papers + Class notes**	**By the end of the module, student will be able to** • Explain the application of nano materials for environmental pollution (air, water, and solid) control. • Explain mechanism of interaction between nanomaterials and the pollutants. • Explain property-nanostructure correlation of the nanomaterials and their effects on pollutants removal. • Define toxic effect of nanotechnology on environment, relative remediation and precautions.

6. Evaluation Scheme:

Component	Duration (min)	Weightage (%)	Date & Time	Nature of component (Close Book/ Open Book)
Mid-Semester Test	**90**	**30**	<TEST_1>	**OB**
Comprehensive Exam	**120**	**35**	<TEST_C>	**OB**
Project Work		**20**		
Quiz (Best 3 out of 4)		**15**		**CB**

7. Chamber Consultation Hour: To be announced in the class

8. Notices: The notices will be displayed on the Chemical Engineering Group notice board and/or Nalanda only

9. Make-up Policy: Make-up will be granted for genuine cases only. Certificate from authenticated doctor from the Medical Center must accompany make-up application (*only prescription or vouchers for medicines will not be sufficient*). Prior permission of IC is compulsory.

- No make up for Quizzes,& Project components

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

Instructor-in-charge
Course No. BITS F429