Course Specification

(Postgraduate Programs)

Course Title: Nanostructures Engineering
Course Code: PHYS 638
Program: Master of Science in Physics
Department: Physics
College: College of Sciences
Institution: Majmaah University
Version: 1
Last Revision Date: 30/12/2024

Table of Contents

A. General information about the course:

1. Course Identification

1. Credit hours: (3)					
2. Course type					
A.	☐University	☐College	☒ Department	☐Track-2	☐Others
B.	☐ Required		☒ Elective		
3. Level/year at which this course is offered: (1st/ 2)					
4. Course General Description:					
Nanostructures Engineering is an advanced postgraduate course that offers comprehensive coverage of the synthesis, characterisation, and application of nanostructured materials. The course examines both top-down and bottom-up fabrication methods, emphasising the fundamental principles governing size-dependent properties in nanoscale systems. Students will gain practical knowledge of various nanofabrication techniques, including lithography, chemical vapour deposition, and solution-based methods. The course integrates theoretical foundations with practical applications across diverse fields, including nanoelectronics, energy storage, and biomedical engineering. Through laboratory demonstrations, research presentations, and critical analysis of current literature, students develop the technical expertise and innovative thinking needed for advanced research and development in nanotechnology.					
5. Pre-requirements for this course (if any):					
Physics and Technology of Semiconductors, PHYS 624					
6. Co-requisites for this course (if any):					
none					
7. Course Main Objective(s):					
1. To comprehensively understand fundamental principles governing nanoscale materials, including quantum confinement effects, surface phenomena, and size-dependent physical and chemical properties. 2. Master various nanofabrication techniques, including top-down approaches (lithography, etching) and bottom-up synthesis methods (CVD, PVD, ALD, sol-gel, and colloidal synthesis). 3. Acquiring proficiency in advanced characterization techniques (SEM, TEM, AFM, XRD, XPS, Raman spectroscopy) for structural, morphological, and compositional analysis. 4. To design and analyze nanostructured devices for applications in electronics, energy conversion and storage, and biomedical technologies. 5. To develop research skills, critical thinking, and professional communication abilities through independent investigation and presentation of current research topics in nanotechnology.					

2. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	45	100%
2	E-learning		
3	Hybrid • Traditional classroom • E-learning		
4	Distance learning		

3. Contact Hours (based on the academic semester)

No	Activity	Contact Hours
1.	**Lectures**	45
2.	**Laboratory/Studio**	
3.	**Field**	
4.	**Tutorial**	
Total		**45**

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
1.0	**Knowledge and understanding**			
1.1	Demonstrate advanced knowledge of fundamental principles of nanotechnology, including quantum confinement effects, surface-to-volume ratio phenomena, and their impact on material properties.	K1	Lectures, interactive discussions, video demonstrations, and problem-solving sessions	Homework, exams
1.2	Master various nanofabrication and synthesis techniques, comparing top-down and bottom-up approaches and selecting appropriate methods for specific applications	K4	Lectures, examples, computational exercises, and problem-solving workshops.	Homework, exams

1.3				
2.0	**Skills**			
2.1	Apply characterization techniques to analyze nanostructures, interpreting data from SEM, TEM, AFM, XRD, XPS, and Raman spectroscopy to determine structural and compositional properties.	S3	Laboratory demonstrations, data analysis workshops, case studies, and hands-on exercises	Homework, exams, presentation
2.2	Design and analyze nanostructured devices for specific applications in electronics, energy, or biomedicine, predicting their performance characteristics	S4	Design projects, simulation software training, group work, and literature review	Homework, exams, presentation
3.0	**Values, autonomy, and responsibility**			
3.1	Communicate scientific findings professionally, presenting research topics clearly and effectively using appropriate scientific terminology and visual aids.	V1	Presentation practice sessions, report writing guidance, peer review, and feedback sessions.	Research Presentation, Class Participation
3.2	Conduct research and demonstrate innovation in nanotechnology by critically evaluating current research literature, identifying research gaps, and proposing innovative solutions.	V3	Literature review assignments, journal club discussions, research seminars, and critical analysis exercises	Research Presentation, Class Participation

C. Course Content

No	List of Topics	Contact Hours
1.	Introduction to Nanotechnology - Size-dependent properties, quantum confinement, surface effects	3
2.	Top-Down Fabrication - Lithography techniques (photolithography, e-beam, nanoimprint). Etching methods	3
3.	Bottom-Up Synthesis - Chemical vapour deposition, physical vapour deposition, atomic layer deposition	3
4.	Solution-Based Methods - Sol-gel, hydrothermal synthesis, co-precipitation, colloidal synthesis	3
5.	Zero-Dimensional Nanostructures - Quantum dots, nanoparticles, nanoclusters. Synthesis and properties	3

6.	MIDTERM EXAMINATION 1	3
7.	One-Dimensional Nanostructures - Nanowires, nanotubes, nanorods. Growth mechanisms (VLS, template)	3
8.	Two-Dimensional Nanostructures - Graphene, transition metal dichalcogenides, thin films	3
9.	Characterization Strategy for Nanostructures - Overview of characterization approaches specific to nanoscale materials. Sample preparation considerations.	3
10.	Property Measurements in Nanostructures - Focus on nanoscale-specific measurement challenges and interpretation. Optical and electrical measurements on nanostructures.	3
11.	Device Applications I - Nanoelectronics: transistors, sensors, memory devices	3
12.	MIDTERM EXAMINATION 2	3
13.	Device Applications II - Energy storage and conversion: batteries, supercapacitors, solar cells	3
14.	Biomedical Applications - Drug delivery, biosensors, tissue engineering, diagnostic tools	3
15.	STUDENT PRESENTATIONS and COURSE REVIEW	3
Total		45

D. Students' Assessment Activities

No.	Assessment Activity	Assessment timing (in week no)	Percentage of Total Assessment Score
1	Homework Assignments (3)	2, 4, 8	5%
2	Quizzes (2)	3, 10	5%
3	**Midterm Examination 1**	**6**	**15%**
4	**Midterm Examination 2**	**12**	**15%**
5	**Research Presentation**	**15**	**15%**
6	Class Participation	1-14	5%
7	**Final Examination**	**Final Week**	**40%**

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.).

E. Learning Resources and Facilities

1. References and Learning Resources

Essential References	C.P. Poole and F.J. Owens, Introduction to Nanotechnology, Wiley, 2003, ISBN: 978-0-471-07935-4 (hardcover). Published by John Wiley & Sons.
Supportive References	G. Cao and Y. Wang, Nanostructures and Nanomaterials, World Scientific, 2011, ISBN: 978-981-4322-50-8 (hardcover), 978-981-4322-55-3 (paperback). Published by World Scientific Publishing.

Electronic Materials	· Wikipedia https://www.wikipedia.org/ · Saudi Digital Library (SDL): https://eservices.mu.edu.sa/sdl · Physics Today (web version) https://www.aps.org/publications/physics-today.cfm · MIT Courseware: https://ocw.mit.edu/index.htm IOP Science: https://iopscience.iop.org/
Other Learning Materials	· Class presentation · Black Board (web-based application – course material) · Hand out · WhatsApp group Software manuals/ user guide

2. Required Facilities and Equipment

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	Classroom (must be the same for the same subject) Seminar room with multimedia Computer lab for (e-Quiz)
Technology equipment (projector, smart board, software)	Blackboard (BB) software/login Whiteboard MS software suite Origin Graphic software Smart board that maintains feedback Laptop, Desktop, and printer with accessories.
Other equipment (depending on the nature of the speciality)	Library, Seminar Room, and Wi-Fi /internet connections.

F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Internal Reviewer Committee	Direct
Effectiveness of Students' Assessment	Students	Indirect
Quality of learning resources	Peer Reviewer	Indirect
The extent to which CLOs have been achieved	Qiyas Centre, Stakeholders and Others	Direct

Assessors (Students, Faculty, Program Leaders, Peer Reviewers, Others (specify)

Assessment Methods (Direct, Indirect)

G. Specification Approval

COUNCIL /COMMITTEE	Physics Department
REFERENCE NO.	16

DATE	30/12/2024