



Course Specification

(Postgraduate Programs)

Course Title: Optical Properties of Nanostructures

Course Code: PHYS 639

Program: Master of Science in Physics

Department: Physics

College: College of Sciences

Institution: Majmaah University

Version: 1

Last Revision Date: 30/12/2024



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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:

Optical Properties of Nanostructures is an advanced postgraduate course investigating the fundamental optical phenomena and applications of nanoscale materials and systems. The course offers comprehensive coverage of light-matter interactions in confined geometries, quantum confinement effects on optical properties, and advanced topics in nano-optics, including plasmonic and photonic crystals. Students will explore how the optical properties of materials change significantly as dimensions are reduced to the nanoscale, leading to novel phenomena and applications. The course emphasizes theoretical understanding and practical applications of emerging technologies, including quantum information processing, optical computing, sensing, and energy conversion. Through analysis of cutting-edge research literature and student presentations, the course fosters critical thinking and research skills essential for innovation in the rapidly evolving field of nanophotonics.

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 establish mastery of essential principles in optical physics, including Maxwell's equations, light-matter interactions, and quantum mechanical treatment of optical transitions in nanostructures.
2. To comprehensively understand quantum confinement effects on optical properties, including size-dependent absorption and emission in quantum dots, nanowires, and two-dimensional nanostructures.
3. To explore advanced topics in nano-optics such as surface plasmon resonance, plasmonic enhancement, photonic crystals, and nonlinear optical phenomena in nanostructures.
4. To gain proficiency in optical characterization techniques and their application in analysing nanostructured materials, including absorption/transmission spectroscopy, photoluminescence, and time-resolved spectroscopy.



5. To design and evaluate optical devices based on nanostructures for use in displays, LEDs, solar cells, sensors, optical computing, and quantum information technologies.

2. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	45	100%
2	E-learning		
3	Hybrid <ul style="list-style-type: none"> • 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	Master fundamental optical physics and quantum mechanics of nanostructures by applying Maxwell's equations and quantum mechanics to explain light-matter interactions, dielectric functions, and optical transitions.	K2	Lectures, interactive discussions, video demonstrations, and problem-solving sessions	Homework, exams
1.2	Understand quantum confinement effects on optical properties by analyzing how size reduction affects electronic structure, density	K4	Lectures, examples, computational exercises, and	Homework, exams



	of states, and optical absorption/emission spectra in various nanostructure geometries.		problem-solving workshops.	
1.3				
2.0	Skills			
2.1	Analyze optical properties using advanced characterization techniques by interpreting experimental data from absorption/transmission spectroscopy, photoluminescence, and time-resolved measurements	S2	Laboratory demonstrations, data analysis workshops, case studies, and hands-on exercises	Homework, exams, presentation
2.2	Design optical devices using nanostructures by designing and optimizing nanostructure-based optical devices (LEDs, solar cells, sensors, lasers), considering material properties, geometry, and application requirements	S3	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 in nano-optics by presenting current research with clarity, accuracy, and appropriate use of scientific terminology and visual representations	V2	Prepresentation practice sessions, report writing guidance, peer review, and feedback sessions.	Research Presentation, Class Participation
3.2	Evaluate and contribute to cutting-edge research in nano-optics by critically analyzing recent research publications, identifying emerging trends and challenges, and proposing innovative approaches	V2	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 Optical Physics - Light-matter interaction, Maxwell equations, dielectric function	3
2.	Quantum Confinement Effects in Nanostructures - Focus on optical implications of quantum confinement. Size-dependent optical properties.	3
3.	Optical Transitions in Nanostructures - Direct/indirect transitions and selection rules specific to confined systems.	3
4.	Quantum Dots I - Electronic structure, size-dependent optical properties, photoluminescence	3





5.	Quantum Dots II - Applications in displays, LEDs, solar cells, biological imaging	3
6.	MIDTERM EXAMINATION 1	3
7.	Nanowires and Nanotubes - Optical anisotropy, polarization effects, waveguiding properties	3
8.	Plasmonics I - Surface plasmon resonance, localized surface plasmons in metal nanoparticles	3
9.	Plasmonics II - Plasmonic sensors, SERS, plasmonic solar cells, metamaterials	3
10.	Photonic Crystals - Band gaps, fabrication, optical properties, photonic crystal fibers	3
11.	Nonlinear Optical Properties - Second/third harmonic generation, two-photon absorption, saturable absorption	3
12.	MIDTERM EXAMINATION 2	3
13.	Optical Characterization of Nanostructures - Focus on interpretation of optical measurements and nanostructure-specific considerations. Time-resolved spectroscopy.	3
14.	Advanced Applications - Optical computing, quantum information, nanolasers, optical switching	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

M. Pelton and G. Bryant, Introduction to Metal-Nanoparticle Plasmonics, Wiley, 2013, ISBN: 978-0-470-61675-8, Published by John Wiley & Sons.





Supportive References	V.I. Klimov, Nanocrystal Quantum Dots, CRC Press, 2010, ISBN: 978-1-4200-7926-3 (2nd edition). Published by CRC Press (Taylor & Francis).
Electronic Materials	<ul style="list-style-type: none"> · Saudi Digital Library (SDL) · https://www.wikipedia.org/ · Web of Knowledge · Physics Today (web version) · MIT Courseware
Other Learning Materials	<ul style="list-style-type: none"> · Class presentation · Desire to learn (D2L) · Equipment manuals/hand out · 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	Direct
The extent to which CLOs have been achieved	Qiyas Center, Stockholder, and Others	Direct

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

Assessment Methods (Direct, Indirect)

G. Specification Approval

COUNCIL /COMMITTEE	Physics Department
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REFERENCE NO.	16
DATE	30/12/2024

