PHYSICS 4520.001
Physics of Nanoscale Materials: **Spring 2026**

Lecture: Phys 311
Day/Time: Mon, Wed, Fri: 11:00 – 11:50 am

Professor: Usha Philipose
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Office Hours: Tuesday: 9:30 a.m – 10:30 a.m., and by appointment

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Course Description: This course is an introduction to nanoscience and nanotechnology. Nanometer is the length scale that bridges the macroscopic world where the properties of matter are treated with classical physics and the microscopic world where the properties of matter are treated with quantum mechanics. Important technological applications become possible as material properties are engineered through size and dimension control to suit specific applications. This course will provide an overview on a broad range of topics and is tailored to benefit Physics, Electrical Engineering and Materials Engineering students. It will provide cross-disciplinary scientific knowledge and also help develop skills that are essential tools in science based tech. industries, government laboratories, and universities.

All course-related communications will be via Canvas. The best way to reach me with questions or concerns is via email at usha.philipose@unt.edu. In most cases, you can expect to receive a response to emails within 24 hours.

Course Objectives:
By the end of the course, you should:
- have knowledge of the fundamental properties of nanoscale systems in terms of their molecular and atomic characteristics
- understand complex nanosystems, which are unique in their operations and possess new functionalities
- gain knowledge in physics, mathematics, material science, and electronics and become proficient in translating this knowledge into useful technological applications
- acquire sufficient scientific background and lab-based skills in the field to undertake research in graduate school or work in an industry.

Course Requirements:
Prerequisites: Physics 3010
Attendance is mandatory and is required for both lecture and labs.

Recommended Text Books: We will be using materials from research publications, books, and instrument manual available in the print and Web. The following books are suggested for review:

(1) "Introduction to Nanoelectronics", V.V.Mitin, V.A. Kochelap, M.A. Stroscio
(2) "Quantum wells, wires and dots", *Paul Harrison*, (Wiley-Interscience, 2005)
(3) "Fundamentals of Semiconductor Physics and Material Properties", *Peter Y. Yu and*

Manuel Cardona, (Springer-Verlag, 1996)

Exams: There will be **two tests** and a **final examination**.

Homework: Homework sets will be assigned each week in lecture. A short research paper based on a short project that will be completed in Lab 320 is required to be submitted. Project topics will be discussed during recitation.

Grading:	Homework:	20%,
	Test 1 and Test 2:	40% (20 x 2)
	Final exam	40%
	Total	**100 %**

Ancillary Materials

Canvas will be used to post some useful course materials and your grades. To get to this resource, go to https://unt.instructure.com/courses and follow the UNT link to log on. (You will log on using your UNT EUID and password.) You will find an electronic copy of this syllabus and copies of the Power Point presentations from lecture. Please note that if you wish to communicate with the instructor via email, you will get a much faster response if you use usha.philipose@unt.edu instead of the mail facility in Canvas.

Related websites

https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/

http://nanosensors.ucsd.edu/ - Ivan Schuller's group @ UCSD

http://www.media.mit.edu/nanoscale/ - Scott Manalis' group @ MIT

http://monet.physik.unibas.ch/nose/ - Basel “Electronic Nose” page

http://www.research.ibm.com/disciplines/physics.shtml - IBM Research - lots of neat topics

Important Note: This course includes an embedded **microcredential in Semiconductor Processing**, available at no additional cost. By successfully completing the microcredential, you will earn a **digital badge** that can strengthen your résumé and be helpful when applying for jobs or graduate school. Participation and performance in the microcredential labs **do not affect your course grade**.

Tentative Lecture Schedule

Class	Date		Topics
1	Jan 12	Introduction to Nanotechnology, Survey of modern electronics	Discussion of the International Technology Roadmap characteristics, New concepts in electronics
2	Jan 14	Trends towards nanoelectronics	From microelectronics towards nano- electronics, Schrodinger wave equation
3	Jan 16	Wave mechanics	Wave mechanics of particles: selected examples
4	Jan 19	MLK Day: No classes	
5	Jan 21	Materials for nanoelectronics	Semiconductors, Electron energy bands
6	Jan 23	Materials for nanoelectronics	Semiconductor heterostructures, lattice-matched heterostructures, pseudomorphic heterostructures
7	Jan 26	Materials for nanoelectronics	Inorganic-organic heterostructures,
8	Jan 28	Growth and fabrication of nanostructures	Carbon nanomaterials, nanotubes and fullerenes
9	Jan 30	Growth and fabrication of nanostructures	Growth of crystals and hetero-structures
10	Feb 02	Growth and fabrication of nanostructures	Nanolithography, etching
11	Feb 04	Growth and fabrication of nanostructures	Techniques for fabrication of nanostructures and nanoscale devices
12	Feb 06	Growth and fabrication of nanostructures	Spontaneous formation and ordering of nanostructures
13	Feb 09	Growth and fabrication of nanostructures	Synthesis of clusters and nanocrystals
14	Feb 11	Growth and fabrication of nanostructures	Nanotube growth methods
15	Feb 13	Growth and fabrication of nanostructures	Chemical and biological methods for nanoscale fabrication
16	Feb 16	Growth and fabrication of nanostructures	Chemical and biological methods for nanoscale fabrication
17	Feb 18	Growth and fabrication of nanostructures	Nano-electromechanical systems

18	**Feb 20**	**Test 1**	**Topics covered in class 1 - 15**
19	Feb 23	Characterization of nanostructures	Electron microscopy
20	Feb 25	Characterization of nanostructures	Atomic force microscopy
21	Feb 27	Characterization of nanostructures	Electrical Transport measurements
22	Mar 02	Characterization of nanostructures	Electrical Transport measurements
23	Mar 04	Characterization of nanostructures	Optical characterization techniques
24	Mar 06	Characterization of nanostructures	Characterization techniques
	Mar 09-15	Spring break No classes	
25	Mar 16	Electron transport in semiconductor nanostructures	Time and length scales of electrons in solids
26	Mar 18	Electron transport in semiconductor nanostructures	Statistics of electrons in solids and nanostructures
27	Mar 20	Electron transport in semiconductor nanostructures	Density of states of electrons in nanostructures
28	Mar 23	Electron transport in semiconductor nanostructures	Density of states of electrons in nanostructures
29	Mar 25	Electron transport in semiconductor nanostructures	Electron transport mechanisms
30	Mar 27	Electron transport in semiconductor nanostructures	Electrons in quantum wells
31	Mar 30	Electrons in low-dimensional structures	Electrons in quantum wires and in quantum dots
32	Apr 01	Nanostructure devices	Field-effect transistors, Single-electron-transfer devices
33	Apr 03	Nanostructure devices	Potential-effect transistors, Light-emitting diodes and lasers
34	Apr 06	Nanostructure devices	Nano-electromechanical system devices Quantum-dot cellular automata
35	Apr 08	Magnetic nano-devices	Magnetic materials
36	Apr 10	Magnetic nano-devices	Magnetoresistance
37	Apr 13	Magnetic nano-devices	GMR effects
38	Apr 15	Magnetic nano-devices	Application of GMR effects: GMR Hard Disk Drives
39	**Apr 17**	**Test 2**	**Topics covered in class 16 - 35**
40	Apr 20	Photonic nanoscale devices	Nano-photonics

41	Apr 22	Photonic nanoscale devices	Light interaction with nano-materials
42	Apr 24	Photonic nanoscale devices	Fluorescent quantum dots, lasing in nanowires, Photonic crystals
43	Apr 27	Review	
44	Apr 29	Review	
45	May 01	Reading Day	
	May 04 (Monday)	**Final Exam**	**10:00 am – 12:00 pm**

Course Evaluation

Student Perceptions of Teaching (SPOT) is the student evaluation system for UNT and allows students the ability to confidentially provide constructive feedback to their instructor and department to improve the quality of student experiences in the course. The survey will be made available to provide students with an opportunity to evaluate how this course is taught. Students will receive an email from "UNT SPOT Course Evaluations via IASystem Notification" (no-reply@iasystem.org) with the survey link. Students should look for the email in their UNT email inbox. Simply click on the link and complete the survey. Once students complete the survey they will receive a confirmation email that the survey has been submitted. For additional information, please visit the SPOT website (http://spot.unt.edu/) or email spot@unt.edu.

Course Policies

Attendance policy: You are expected to attend all remote lectures and the lab sessions. Your grade will depend upon your attendance and participation in class. Visit the University of North Texas' Attendance Policy (http://policy.unt.edu/policy/15-2-) to learn more.

UNT Policy Statements

Academic Integrity Standards and Consequences: According to UNT Policy 06.003, Student Academic Integrity, academic dishonesty occurs when students engage in behaviors including, but not limited to cheating, fabrication, facilitating academic dishonesty, forgery, plagiarism, and sabotage. A finding of academic dishonesty may result in a range of academic penalties or sanctions ranging from admonition to expulsion from the University.

ADA Accommodation Statement: UNT makes reasonable academic accommodation for students with disabilities. Students seeking accommodation must first register with the Office of Disability Accommodation (ODA) to verify their eligibility. If a disability is verified, the ODA will provide a student with an accommodation letter to be delivered to faculty to begin a private discussion regarding one's specific course needs. Students may request accommodation at any time; however, ODA notices of accommodation should be provided as early as possible in the semester to avoid any delay in implementation. Note that students must obtain a new letter of accommodation for every semester and must meet with each faculty member prior to implementation in each class. For additional information see the ODA website at disability.unt.edu.

Emergency Notification & Procedures: UNT uses a system called Eagle Alert to quickly notify students with critical information in the event of an emergency (i.e., severe weather, campus closing, and health and public safety emergencies like chemical spills, fires, or violence). In the

event of a university closure, please refer to Blackboard for contingency plans for covering course materials.

Sexual Assault Prevention: UNT is committed to providing a safe learning environment free of all forms of sexual misconduct, including sexual harassment sexual assault, domestic violence, dating violence, and stalking. Federal laws (Title IX and the Violence Against Women Act) and UNT policies prohibit discrimination on the basis of sex, and therefore prohibit sexual misconduct. If you or someone you know is experiencing sexual harassment, relationship violence, stalking, and/or sexual assault, there are campus resources available to provide support and assistance. UNT's Survivor Advocates can assist a student who has been impacted by violence by filing protective orders, completing crime victim's compensation applications, contacting professors for absences related to an assault, working with housing to facilitate a room change where appropriate, and connecting students to other resources available both on and off campus. The Survivor Advocates can be reached at SurvivorAdvocate@unt.edu or by calling the Dean of Students Office at 940-565- 2648. Additionally, alleged sexual misconduct can be non-confidentially reported to the Title IX Coordinator at oeo@unt.edu or at (940) 565 2759.