School of Electrical and Computer Engineering
Milind Kulkarni
Associate Head of Teaching and Learning

To: The Engineering Faculty
From: School of Electrical and Computer Engineering
Re: ECE 30653

The School of Electrical and Computer Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

ECE 30653 Introduction to Nanotechnology and Quantum Science & Technology
Semesters offered: Spring
Non-repeatable
Credit 3

Pre-requisites:
MA 26100 and (MA 26600 or MA 26200) and (PHYS 27200 or PHYS 24100) and (CHM 11500 or (CHM 11100 and CHM 11200))

Course Description

The "staggeringly small world" of devices with atomic scale size and remarkable properties has been shaping both fundamental science and the field of nanotechnology for more than two decades. Today, a new, Quantum technology revolution is upon us where both macrometer- and nanometer-scale systems are seamlessly integrated into exotic quantum science leading to exploration of quantum computers, secure communication and more. This interdisciplinary course offers an introduction to nanotechnology and quantum science and technology for undergraduate students in science and engineering. The students will develop understanding of interdisciplinary nature of these fields and utilize concepts in physics, chemistry and mechanics to describe and analyze unique properties of quantum and nanoscale objects. The course will provide the opportunity to get exposed to highly interdisciplinary nature of today's most active and rapidly expanding fields of research and technologies.

Reason
This is a new course in the ECE Microelectronics and Nanotechnology area to provide more courses/content in the quantum field. This course will be cross-listed with three, 1-credit ENGR courses to provide FYE students an introduction to nanotechnology and quantum science.

History of Previous Offering
Enrollment History: Spring 2020=17, Spring 2019=10

Milind Kulkarni

Associate Professor of ECE & Associate Head of Teaching and Learning

ECE 30653/ ENGR 10301
Introduction to Nanotechnology and Quantum Science and Technology

Credits: 3
ELECTRICAL ENGINEERING CREDIT ECE 39595 Week 1-15
Credits: 1
ENGR 10301A 21038-002 Week 1-5
ENGR 10301B 21043-003 Week 6-10
ENGR 10301C 21044-004 Week 11-15

Info: Spring Semester 2020, Lectures **Tue/Thu TR 03:00 pm-04:15 pm, EE 115**
In this document, the course policies and procedures, communication, grading, quizzes, homework, projects, academic honesty, and available resources are outlined.

Course website: Blackboard Learn https://mycourses.purdue.edu

Instructor: Alexandra Boltasseva - Birck 1295/EE333 (Phone: 494-0301 aeb@purdue.edu)
Urgent matters: via email (I always check my email outside working hours!)
Office hour: Thursday 2-3pm, EE333
Questions/discussions after the class are encouraged. *Individual meetings can be scheduled but please send an email request at least one day before.*

Course Description: The "staggeringly small world" of devices with atomic scale size and remarkable properties has been shaping both fundamental science and the field of nanotechnology for more than two decades. Today, a new, Quantum technology revolution is upon us where both macrometer- and nanometer-scale systems are seamlessly integrated into exotic quantum science leading to exploration of quantum computers, secure communication and more. This interdisciplinary course offers an introduction to nanotechnology and quantum science and technology for undergraduate students in science and engineering. The students will develop understanding of interdisciplinary nature of these fields and utilize concepts in physics, chemistry and mechanics to describe and analyze unique properties of quantum and nanoscale objects. The course will provide the opportunity to get exposed to highly interdisciplinary nature of today's most active and rapidly expanding fields of research and technologies.

Course Goal: Students will develop understanding of interdisciplinary nature of nanotechnology and quantum technology and utilize concepts in physics, chemistry and mechanics to describe and analyze unique properties of nanoscale objects.

Course Prerequisites and Co-requisites: Basic college physics and mathematics: MA 26100, MA 26600 or MA 26200; PHYS 27200 or PHYS 24100.

Text:
1. Luanne Tilstra, S. Allen Broughton, Robin S. Tanke, Daniel Jelski, Valentina French, Guoping Zhang, Alexander K. Popov, Arthur B. Western and Thomas F. George, *The Science of Nanotechnology: An Introductory Text*. Nova Science, 2008. (SNIT)
2. T. Pradeep, *Nano: The Essentials.* Tata McGraw-Hill, 2007. (NANO)
Recommended additional reference(s):
1. Richard P. Feynman, "Plenty of Room at the Bottom" (RF)
2. Guozhong Cao, *Nanostructures and Nanomaterials*. World Scientific, 2004. (NSNM)

3. James E. Morris, “Nanopackaging: nanotechnologies and electronics packaging,” Springer US, 2008. (NP)

Grading: Each student’s course grade will be based upon the total numerical score he or she earns, with the following point allocation:

	ECE395	ENGR10301A	ENGR10301B	ENGR10301C
Homework/Assignments	30%	50%	50%	50%
In-class quizzes	30%	50%	50%	
Presentation of the final project	40%			50%

The grading scheme outlined above takes into account the Course Outcomes, as defined in our ABET accreditation standards, for which each student must demonstrate a minimum level of competency. These course outcomes are outlined in the next section.

Learning Objectives/ Course Outcomes:

A student who successfully fulfills the course requirements will demonstrate the following abilities:

Outcome i) Define, distinguish between and recognize major types of nanoparticles, their characteristic properties and their sources [1]

Outcome ii) Illustrate by calculations and numerical tools the physical properties of nanoscale objects, e.g. calculate de Broglie wavelength, surface energy, melting point [1]

Outcome iii) Describe basic nanostructure fabrication and measurement methods [1]

Outcome iv) Investigate broader technological and societal impacts and give examples of economic benefits of nano and quantum technology [3,4,5,7]

Outcome v) Describe approaches for managing security, health and environmental risks of nanotechnology and quantum technologies [3,4,5,7]

You will have multiple opportunities to satisfy these ABET outcomes through the homework, quizzes, class participation, and final project. The questions will be based on these Course Outcomes. You will satisfy each Course Outcome when your score for the corresponding assignments equals or exceeds a value we specify as representing a minimal competency. If you fail to meet this level of minimal competency on a specific Course Outcome, you will have more opportunities, for example, via additional assignments that cover overlapping materials. Typically, students otherwise doing well in the course will readily satisfy all Course Outcomes.

Assignments/Homework:

- *Doing the homework is the only way to truly learn the subject matter. Students who do not work the homework themselves typically do not perform well in the course.*
- Due at the beginning of the class period – unless I tell otherwise and go through some HW points in class. In this case it is due at the end of the class.
- No late homework is accepted.
- You may work together as you solve your homework problems, as this can be an effective means of learning the material. If you do work in a group, please be sure that the solution you turn in is your own work. You will receive reduced or zero credit for homework submissions that appear to be copies of each other.
- For written assignments, please write your solutions legibly and in an organized manner so that the grader can follow your work easily and, where possible, place your final answer in a box.
- Solutions to the homework assignments are posted online shortly after they are due.

General Course Policies: The students are welcome to ask questions/notify the instructor/TA via emails. No cell phones/computers use in class unless the student is using them to take notes. But please keep your cell phone ON to receive a Purdue ALERT text message.

Use of Copyrighted Materials: It is requested that students do not make course notes or materials available for others. The University Regulations: 'Always assume the materials presented by an instructor are protected by copyright unless the instructor has stated otherwise. Students enrolled in, and authorized visitors to, Purdue University courses are permitted to take notes, which they may use for individual/group study or for other non-commercial purposes reasonably arising from enrollment in the course or the University generally'.

Academic Dishonesty: The ECE faculty expects every member of the Purdue community to practice honorable and ethical behavior both inside and outside the classroom. Any actions that might unfairly improve a student's score on homework, quizzes, or examinations will be considered cheating and will not be tolerated. Examples of cheating include (but are not limited to):

Sharing results or other information during an examination.
Bringing forbidden material or devices to an examination.
Working on an exam before or after the official time allowed.
Requesting a regrade of answers or work that has been altered.
Submitting homework that is not your own or engaging in forbidden homework collaborations.

At the instructor's discretion, cheating on an assignment or examination will result in a reduced score, a zero score, or a failing grade for the course. All occurrences of academic dishonesty will be reported to the Assistant Dean of Students and copied to the ECE Associate Head for Education. If there is any question as to whether a given action might be construed as cheating, please see the instructor before you engage in any such action.

Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing integrity@purdue.edu or by calling 765-494-8778. While information may be submitted anonymously, the more information that is submitted provides the greatest opportunity for the university to investigate the concern.

Class Attendance: Your attendance in class is important. If you must miss a class, you are responsible for any material, information, handouts, announcements, etc. that you missed. Since participation is a key part of your grade, repeated absences will detract from your overall grade. Late arrivals and early departures from class can be disruptive, so please keep these to a minimum.

Campus Emergency: In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances. In such an event, information will be provided through Blackboard Learn.
Please keep your cell phone ON to receive a Purdue ALERT text message.

Students with documented disabilities: The Disability Resource Center (DRC) is a resource for students and instructors. Students may present a "Letter of Accommodation" to you at any point in the semester. Should you have questions about accommodations, please contact the DRC at: 494-1247 or drc@purdue.edu. In many cases the DRC can partner with you to develop inclusive teaching strategies that benefit all students in your class.

Accessibility and Accommodations Syllabus Statement: The DRC recommends the following statement be included in your syllabus. "Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact

the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247." http://www.purdue.edu/drc/faculty/syllabus.html

Tentative Lectures Schedule ECE 39595

(Dates are subject to change – please check BB regularly!)

Lec #	Topics	Reading Assignment
	Introduction to Nanotechnology: World of Nanoparticles (ENGR 10301A)	
1-01/14	Course overview. What is NANO? Introduction to nano- and quantum worlds. Nanotechnology today.	RF, NANO 1.2-1.4, SNIT 1.1-1.2, NSNM 1.1-1.2
2-01/16	Basics of quantum physics. De Broglie waves, and the wave-particle duality of matter and light.	Notes
3-01/21	Definition and types of nanoparticles.	SNIT 1.3-1.4 **Assignment#1 due**
4-01/23	Nanoparticle synthesis. Surface energy.	NP 6.1-6.2, SNIT 3, NSNM 2.1-2.2 **HW#1 due**
5-01/28	Van der Waals force. Double layer force.	NSNM 2.4
6-01/30	Capillary force. Electrostatic stabilization.	NSNM 2.5, SNIT 3 **HW#2 due**
7-02/04	Physical, electric and chemical properties.	NP 5.1-5.8, SNIT 5
8-02/06	Metal nanoparticles (MNP)	Notes **HW#3 due**
9-02/11	MNP: Sunscreen&Anti-bacterial, Color change.	Notes
10-02/13	In-class Quiz I	**QUIZ I**
	Nanotechnology Around Us (ENGR 10301B)	
11-02/18	Nanoparticles. Pollution control. Environmental and safety concerns.	NP 6.3, Notes
12-02/20	MNPs for photocatalysis, desalination and more.	Notes **CP#1 due**
13-02/25	Ceramic and polymeric nanoparticles.	NANO 3.2-3 **Assignment#1 due (ENGR only)**
14-02/27	Fullerene synthesis and properties, applications.	NANO 3.4,3.8-3.12 SNIT 3 **HW#4 due**
15-03/03	Carbon nanotubes (CNTs): Structure	NANO 4.2, SNIT 4
16-03/05	CNT: Structure, conductivity, synthesis	NANO 4.3, SNIT 4 **CP#2 due**
17-03/10	CNT properties and applications	NANO 4.4-4.9
18-03/12	Quantum dots (QDs) and wells: Physics and Synthesis	NANO 7.2-4, 7.7, SNIT 6.6
	SPRING BREAK	
19-03/24	Quantum dots (QDs) and wells applications.	Notes **HW#5 due**
20-03/26	In-class Quiz II	**QUIZ II**
	Introduction to Nano- and Quantum Technology (ENGR 10301C)	
21-03/31	Nanotechnology cleanrooms. Experimental tools for nanotechnology. Physics of electron microscopy.	NANO 7.2-4,7.7, SNIT 6.6, Notes NANO 2.2-2.3, SNIT 2.1
22-04/02	Scanning, transmission electron microscopy. Scanning tunneling microscopy. Atomic force microscopy. **Final projects introduction**.	NANO 2.4, SNIT 2.2
23-04/07	Novel applications of nanotechnology. Super-resolution microscopy.	Notes **Assignment#1 due (ENGR only)**

24-04/09	Introduction to Quantum Information Science and Technology. Basics of quantum physics.	Notes **HW#6 due**
25-04/14 26-04/16	Introduction to wave mechanics: Schrödinger's equation, wave functions, probability amplitudes. Heisenberg uncertainty principle.	Notes Notes **HW#7 due** **Project proposals due**
27-04/21 28-04/23	Intro to quantum computing, communication and quantum sensors. **Final projects presentations**	Notes ---
29-04/28 30-04/30	**Final projects presentations** Where Nanotech and Quantum Science really happen? Birck Nanotechnology Center Exploratory Lab Tour	--- Meet at 3pm in Birck Atrium