

Dr. Rama Balasubramanian (a.k.a) Dr. Bala

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Office Hours: MW: 2.30-3.30pm; Th 1.10-2.10 pm; Other Hours: By Appointment

Course Overview:

21st century is a technology centric century and innovation in nanoelectronics and nanomaterials will drive the technologies of future. A revolution in electronics technology that started with the invention of a transistor in 1947 and integrated chips in the 1970s has continued on today, resulting in devices that are only 10s of atoms wide. Nanotechnology, a study of properties and application of materials ranging from 1-100 nm, allows scientists to manipulate and control individual atoms and molecules to develop devices that can meet the demand for smaller and faster devices. Nanotechnology has implications in a wide variety of fields such as physics, chemistry, biology, engineering, materials science, bio-medical engineering and engineering. This course will introduce the fundamental principles of nano-science in order to understand the collective behavior atoms and molecules for developing new applications in nanotechnology.

Learning Outcomes: Upon completion of this course, successful students will be able to

- trace modern technologies to development of transistor electronics
- understand quantum mechanical formulations and foundations of nanotechnology
- explain the theory of semiconductors and provide common examples and their use
- describe nanostructure fabrication methods and characterization techniques
- understand the role of nanomaterials for future applications

Topics in micron scale technologies such as physical properties of semiconductor materials and methods of growing crystals will be emphasized by investigating the electronic structure of atoms and the interaction between atoms and electrons. A broad overview of crystal structure, electrical, thermal, magnetic properties of electronic materials, composites and nanostructures will be provided. *The properties of materials will be described in terms of* principles of classical and quantum theories.

A brief introduction to quantum mechanics will be provided and students will be introduced to necessary mathematics along the way to solve the wave equations of simple 1, 2, 3 dimensional problems. Specific mechanisms by which current flows in a solid will be addressed and fundamental concepts of charge transport will be explained. Students will be introduced to the workings of a p-n junctions, the equilibrium state of the junction, the flow of electrons and holes across a junction. Most importantly, students will gain the knowledge about the operations, and applications of several nano-electronic devices.

Nanoscale device fabrication techniques, namely top-down and bottom -up methods will be introduced. Issues involved in miniaturizing the electronic devices from micron scale to the nanoscale will be addressed. The latest trends in field of nano-electronic devices and their applications will be explored by studying the properties of graphene and carbon nanotubes based technologies.

Through this course students will be able to understand and appreciate the foundations of modern technologies. They will become conversant in real-world applications, especially in hardware technology through a study of sound theoretical framework and practical devices.

Required Text: Nanophysics and Nanotechnology by Edward L. Wolf 3rd Edition, Wiley VCH

Other recommended readings:

- Principles of Physics, 4th Edition with Modern Physics, Raymond A. Serway and John W. Jewett, Jr. Thomson/Brookscole (2006)
- Electronic Properties of Material, Hummel, 3rd ed.
- Modern Physics for Scientists and Engineers: 4th Edition, Stephen Thornton and Andrew Rex.

Grading: Grades for this course will be based on homework assignments, tests, quizzes, in-class assignments and student participation.

Homework	15%
2 Midterm Tests (15% each)	30%
Weekly Quizzes	10%
In-class work + Participation	10%
Project Presentation	10%
Final Exam	25%
Total	100%

Points	Grade	Points	Grade
<60	F	76-79	C+
60-62	D-	80-82	B-
63-65	D	83-85	B
66-69	D+	86-89	B+
70-72	C-	90-94	A-
73-75	C	≥95	A

Explanation of the grading scale: The grades will be determined at the end of the semester, on absolute point scale of 100 points. The weighted % point for each assessment type is listed in the table above. For example, a student must have total points of 95 or above to receive an A grade.

Philosophy: My teaching philosophy is not to make you memorize equations but rather help you understand the basics Physics. You must move away from rote memorization and regurgitation to pass this course. I am willing to work with you, if you need extra help. Please talk to me if you have any problems understanding the materials presented. **ASK QUESTIONS; GET YOUR DOUBTS CLEARED WITHOUT PROCRASTINATION.** Feel free to stop by my office. I believe that questions and clarifications are best addressed in person rather than via emails and phone. I urge you to take full advantage of my office hours to get your questions answered.

Attendance: Students are required to attend every class. Attendance will be recorded during every class meeting. Any student who misses a total of four classes will be dropped from the course with a grade of DF. This includes both excused and unexcused absences. A warning email will be sent after the third absence occurs. This will be cc-ed to your academic advisor and registrar.

Absences will also include the following:

If a student shows up for class 10 minutes late/walk out in the middle of the class/caught napping/texting/ checking emails, he/she will be marked absent. In addition, I will consider texting/checking emails/browsing internet all as a form of violation of professional academic code. I will count it as AI violation and will report as one. A physical presence alone does not construe as being present in the class.

Excused Absence: Any unexpected absence due to health reasons/emergency situation/participation in a conference or sporting events representing the College should be supported by proper documentation such as doctor's note, court order, and schedule of conference/sports events. You will need to inform me prior to the absence or within 48 hours of such an absence to be considered as excused. It is best to inform me about your absence in person. Emails and phone voice messages are not very reliable. It is your responsibility to make up for the

work that you missed. I will not extend the deadline for turning in homework or other work assigned in the class unless you have my prior approval.

Homework: This is an important component of your learning and accounts for 15% of your grade! Your homework grade is worth as much as one of the midterm tests. **It is a BIG DEAL.** There will be one homework set each week, consisting of problems from the lectures given during the week. You must work on the homework problems on your own, and keep a copy of the homework with all your work in your Phys 299 course binder. Copying homework solutions from others or other resource materials is not allowed. Copying solutions is a violation of the Academic Integrity policy and there will be severe penalty for AI violation.

Quizzes: These will be about 10 minutes long and will be held during the lecture time. The quiz date will be announced one lecture period prior to the quiz date. They will consist of 3-5 questions from the homework and lecture material. There will be no make-up for the quizzes – if you are absent, you get zero. It is very important that students keep up with the lecture materials and class assignments in order to do well on quizzes.

Expectations: In order to successfully complete this course, all assigned work both in class and homework should be turned in on time. Students are expected to put in a minimum of 8-12 hours/week of work outside class meetings.

Assignments: You will have weekly assignments. A variety of suggested problems are available in the reading list. Students are expected to complete all the assignment problems and submitted on/ before the deadline. A quick check on the completion of the problems will be recorded for assignment grade. A detailed schedule of reading assignments, problem sets and due dates can be found in the reading list. Assignments are due, typically, on Mondays, before the beginning of the class meeting. **You will have to work on the assignments on your own. Any unauthorized help given or taken will be in violation of academic integrity rules.** Late assignments will not be accepted.

Class Activity: I will be assigning journal articles, case studies and problems sets for discussions. Students are expected to complete those, sometimes individually other times as a group. For group activities, class will be divided into several teams. Each team member will have specific tasks and should be prepared to present an overview of the assignment to the entire class at the end of specific activity. More details will be provided inclass at the appropriate time.

Class Disruption: All students are entitled to a professional learning environment. Students should not act in a manner which will distract and disrupt the learning experience. Such practices will not be tolerated. **Cell-phones, or any other electronic communication/entertainment devices, except for the ones approved must be turned off** at all times during the lecture period. If you must use a tablet/laptop for taking notes, make sure you turn off the wifi or keep it in airplane mode.

MCSP Colloquium Series: You are required to attend at least 2 of the several talks as a part of the MCSP colloquia this fall. You should submit a 1 page reflection paper, using turn it in link, within 48 hours of the talk to get credit. Simply regurgitating the talk will get you only ½ the credit. For example if you attend a talk on statistics theme, you should make connections to the statistical concepts you have learnt. MCSP credits, a maximum of 2 extra points, will be added to your course total. This can swing the needle between a + /-. Do not wait till the end of the semester to attend one of these talks, as you may run out of options. You should make connections to courses in the

MCSP curriculum, as much as possible. A schedule of this semester's talk can be found on MCSP webpage.

Midterm Tests: There will be two tests during the semester. These will be held during the class time on Oct 6th and Nov 20th. Each test will cover the material listed on the syllabus or as informed in the class, prior to the tests.

Final Exam: Yes, there will be a final exam at the end, and it is cumulative! It is scheduled on Dec 12th from 8.30-11.30am.

Inquire: Log-in to Inquire program via MyRC web portal on the College website. This will give you access to the syllabus, office hours schedules, lecture notes, any class announcements and a bunch of other stuff. Regular updates will be available posted here. Make sure to check the Inquire website regularly!!! No excuses can be made and no extensions can be granted if you miss a deadline that was posted on Inquire.

Academic Integrity: Policies of Academic Integrity of Roanoke College are enforced in all aspects of this course. It is the responsibility of the student to strictly adhere to the policies of Academic Integrity of Roanoke College. If you are unsure of AI policies, please come and see me.

Additional Learning and Academic Resources:

The Writing Center @ Roanoke College is located in the Goode-Pasfield Center for Learning and Teaching in Fintel Library. Student writers working in any field of study at any level of competence meet with trained peer writing tutors in informal, one-on-one sessions. Writers may meet with tutors at any point in the writing process, from brainstorming to drafting to editing. Simply stop in or schedule an appointment ahead of time by going to MyRC: Academics and looking for the Writing Center Schedule link. The Fall schedule will be posted at www.roanoke.edu/writingcenter

Subject Tutoring, located in the Goode-Pasfield Center for Learning and Teaching in Fintel Library, is available in various academic subjects such as Business & Economics, Foreign Languages, Lab Sciences, Math, CPSC, Statistics, and Social Sciences. All subject tutors are recommended by faculty members and receive training before working with students. Hours vary by subject, so be sure to visit our homepage for a complete list of tutorial hours: www.roanoke.edu/tutoring.

The Office of Special Services: The Office of Special Services provides reasonable accommodations to students with identified disabilities. Although Roanoke College does not have special programs for students with disabilities; reasonable accommodations are provided based on the diagnosed disability and the recommendations of the professional evaluator. In order to be considered for special services, students must identify themselves to the Office of Special Services. Students are required to provide specific current documentation of their disability. Reasonable accommodations may include but are not limited to the following: extended time for tests and examinations, testing in a semi-private testing area, proctoring of examinations, use of interpreters, assistive technology, audio recording of lectures, and/or student note-takers. For additional information please contact Pam Vickers, Special Services Coordinator, at 540-375-2247 or email vickers@roanoke.edu .