"The computing power available on a given chip will double every eighteen months." — Gordon Moore

"Even if you are on the right track, you will get run over if you just stand there." — Will Rogers

"The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn." — Alvin Toffler

**Professor:** Dr. A. Anil Kumar  
**Office:** Room 330C, New Science Building  
**Phone:** (936)857-2591 (Office), (281)890-0848 (Home)  
**E-mail:** aakumar@pvamu.edu, akumar3@houston.rr.com  
**Lectures:** Thursday 2 P.M. – 4:50 P.M., New Science Building  
**Office hours:** By appointment

**Books for the course:**
3. Solid State Physics and Semiconductors, a number of useful links [http://members.tripod.com/~IgorIvanov/physics/solidstate.html](http://members.tripod.com/~IgorIvanov/physics/solidstate.html)

**Supplementary Material: General Texts**

**Supplementary Material: Reference Books**
**COURSE ORGANIZATION**

This is a graduate level course and as such it emphasizes research. The course will be organized into lectures by me, a few lectures by guest speakers and interactive sessions among us. Each interactive session will be in the form of brief presentations by each student, followed by a round table discussion. Multiple views, pros and cons, technical vs. economic feasibility, etc. will be discussed. A topic for the interactive session will be assigned one to two weeks ahead of time.

**COURSE DESCRIPTION**

Catalog Description: Development and analysis of solid state physics needed for quantitative modeling of electronic materials and solid state electronic devices and their characteristics; relationship of basic principles to measurable electrical characteristics, structure and material properties of electronic devices.

The purpose of this course is to provide you with the knowledge and techniques that are central to an understanding of the performance of solid state materials and devices, which include semiconductor, superconductor, magnetic and electronic devices, at the micro- and smaller levels. The lectures will discuss the latest advances in solid state and condensed matter physics, discuss analytical models of devices, and most importantly, emphasize the importance of modeling material and device behavior in response to external perturbations such as the electric and magnetic fields. Also included will be a discussion of optoelectronic devices, photonic devices and quantum devices. Performance of these devices under stress, such as radiation, their operational failures and failure mechanisms, and their reliability will be discussed towards the end.

**GOALS**

By the end of the course, you should be able to, at a minimum:

- Explain the various concepts relevant to material and device physics and performance;
- Demonstrate comprehension of microscopic phenomena and models of electronic transport;
- Demonstrate an understanding of known device building blocks and associated mathematical modeling techniques;
- Compute relevant macroscopic quantities (current, capacitance, conductance, power, etc.) in terms of microscopic quantities (carrier densities, doping concentrations, etc.);
- Correlate the changes in microscopic parameters to the macroscopic behavior of a given device/system;
- Develop a systematic approach to small circuit/system modeling;
- Analyze qualitatively small circuits such as logic gates and memories in terms of the behavior of their device components; and
- Predict qualitative and quantitative behavior of novel devices in various configurations.

**TOPICS COVERED**

Introduction & Motivation; Review from Quantum Theory and Solid State Physics; Basic review of semiconductor physics and relevant equations; Models of atom, chemical bonding, and systems with small number of particles; Energy levels and energy bands; Empirical relationships between microscopic material properties and
macroscopic measurements; Models of electronic transport; Applications to Very Large Scale Integrated (VLSI)/Ultra Large Scale Integrated (ULSI) Device Technologies; p-n Junctions; Junction Field Effect Transistors (JFET); Metal Oxide Semiconductor Capacitors (MOS-C); Metal Oxide Semiconductor Field Effect Transistors (MOSFET); Complementary Metal Oxide Semiconductors (CMOS) Devices; Devices and Circuits - inverters, sensors, charge coupled devices (CCDs), memories; Novel Solid State Devices - superconducting junctions, ferroelectric memories, non-traditional semiconductors, sensors; Special Topics - reliability and fault-tolerance, failure mechanisms, electromigration, radiation effects, thermal effects, nano-scale devices, quantum devices.

PERFORMANCE EVALUATIONS

Homework
I will be assigning several problems throughout the semester. However, I will assume a certain level of maturity and independence from you. In other words, I will not be “policing” you. However, student notebooks should be maintained regularly and will be evaluated at the mid-term and at end of the course. These notebooks should include, at a minimum: research papers, examinations, take home assignments, homework problems, other worked out problems and term papers.

Examinations
There will be two examinations - a mid-term and a final. Each examination will consist of a take-home part and an in-class part.

Technical Papers
Four technical papers are required during the semester.
2. Profile of a company involved in the design, manufacturing and marketing of solid state devices.
4. A Final Term Paper, to be submitted at the end of the semester, on a topic related to the class material. The paper should be fashioned after a published paper in the IEEE Transactions on You are expected to make a presentation on your project to the class during the last two weeks of the semester. Details will be discussed in the class.

Panel Discussions
You are expected to participate in two panel discussions that should enhance your perspective in the field of solid state and semiconductor industry by combining knowledge of the science and engineering with the real world aspects.

Special Presentation
You will be given a published paper/report. You are expected to review the paper/report and present the review to the class.

GRADING POLICY
Your grade, in particular the final grade, will be determined on a combination of your examination performance, design projects and your participation in the class: asking questions, working out problems, making suggestions toward alternative ways of solving the same problem - in other words, behaving like students, not like stenographers. In order to obtain a proper grade, I need to be convinced that you have acquired the necessary knowledge from the course. The
following is the overall grade distribution among the various types of assignment.

<table>
<thead>
<tr>
<th>Assignment Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-Term Examination</td>
<td>15%</td>
</tr>
<tr>
<td>Special Presentation</td>
<td>10%</td>
</tr>
<tr>
<td>Technical Papers (3)</td>
<td>30%</td>
</tr>
<tr>
<td>Panel Discussions (2)</td>
<td>10%</td>
</tr>
<tr>
<td>Final Term Paper</td>
<td>15%</td>
</tr>
<tr>
<td>Final Examination</td>
<td>20%</td>
</tr>
</tbody>
</table>

No makeup examinations will be given except in cases of emergency. No "I"s will be given, unless the stringent conditions specified in the University Catalog are satisfied.

STUDENTS WITH DISABILITIES

If you need accommodations in this class related to a disability, please make an appointment with me as soon as possible. My office is located in Room 330C, New Science Building. The building is accessible to people with disabilities. There is an Office of Disability Services on the campus located in Evans Hall Room 315, Tel: (936)857-2610. More information is available on page 39 of the REVISED Registration and Term Information Fall 2005. ([http://acad.pvamu.edu/content/registrar/files/fall2005_revised.pdf](http://acad.pvamu.edu/content/registrar/files/fall2005_revised.pdf)).

CONDUCT AND ETHICS

A strict code of ethics will be imposed in the class and in the examinations. It is a sign of impoliteness and disrespect to your professor and to your colleagues if you make a practice of coming to the class late. Absolutely no talking or cheating will be permitted during the examinations. You shall take a pledge that you will not copy, steal or plagiarize someone else's work nor will you tolerate anyone else doing the same. It shall be the policy in this course to discourage any such activity to the extent possible rather than punish. HOWEVER, IN FAIRNESS TO ALL CONCERNED, CHEATING AND PLAGIARISM WILL BE DEALT WITH SEVERELY WHEREVER THEY ARE FOUND. Examples of cheating and plagiarism include but are not limited to:

- Sharing results or other information during an examination.
- Submitting homework that is not your own work.
- Reading another student's homework solution before it is due.
- Allowing someone else to read your homework solution before the assignment is due.
- Copying published work on paper or on the Internet and submitting as your own.

Such acts may result in a reduced score, a zero score, or a failing grade for the course depending on the severity of the incident as I judge it. All occurrences of academic dishonesty will be reported to the Dean of Engineering and copied to the Dean of Graduate School. For an interesting discussion on Does the IEEE’s Code of Ethics Meet Today’s Needs?, see the paper by George McClure at [http://www.todaysengineer.org/2004/Aug/ethics.asp](http://www.todaysengineer.org/2004/Aug/ethics.asp). For an instance of what can happen when ethical principles are breached, see [http://physicsweb.org/article/news/6/9/15](http://physicsweb.org/article/news/6/9/15).

You are advised to read and abide by the rules and the regulations of the University as mentioned in the Catalog, in particular the topics Student Life and Academic Regulations. Graduating means more than completing a certain number of hours and obtaining a reasonable GPA. You must strive to develop a code of
strict conduct, acquire a sense of discipline, serve as a role model to your juniors and in particular experience the feeling of accomplishment.

If you have any questions or have any problems that you think I may be able to help with, please do not hesitate to contact me. I am here to help. Learning does hurt. But I am here to make it hurt a little less.

HAVE A PRODUCTIVE AND AN ENJOYABLE SEMESTER!
IEEE CODE OF ETHICS

We, the members of the IEEE, in recognition of the importance of our technologies in affecting the quality of life throughout the world, and in accepting a personal obligation to our profession, its members and the communities we serve, do hereby commit ourselves to the highest ethical and professional conduct and agree:

1. To accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;
2. To avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist;
3. To be honest and realistic in stating claims or estimates based on available data;
4. To reject bribery in all its forms;
5. To improve the understanding of technology, its appropriate application, and potential consequences;
6. To maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;
7. To seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;
8. To treat fairly all persons regardless of such factors as race, religion, gender, disability, age, or national origin;
9. To avoid injuring others, their property, reputation, or employment by false or malicious action;
10. To assist colleagues and co-workers in their professional development and to support them in following this code of ethics.