ELEC 4700 - The Physics and Modeling of Advanced Devices and Technologies

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Course Description:

The course deals with numerical modeling of physical systems. It focuses on a number of numerical techniques based on both event/agent behavour (MD and MonteCarlo) and the use of finite differences for simulating distributed systems. Examples from the fabrication, operation and modeling of advanced devices for information technology are used. Topics: numerical techniques, physics of materials, quantum mechanics of solids, optical transitions, physical analysis and models for state-of-the-art electronic/optical technologies and materials. Technologies: MOS and III-V based transistors, solid-state optical devices, MEMS and nano-technology based devices.

Book of use but not needed::
Principles of Electronic Materials and Devices
Safa Kasap
http://highered.mcgraw-hill.com/sites/0072957913/

Course Requirements:
Exam 35%
Assignments/Projects: 45%
PA Session Work (pass/fail): 20%

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Problem Assignments:
You will get one free pass on a PA without a Doctors note.

Assignments and Project:

There will be 4 assignments. Assignments will be submitted and marked by the TA and then the TA will review the assignment and mark with the student.

The last two are optional and can be replaced with a simulation project. You will have to do a report and presentation on the project. *The topic should be discussed with the instructor.*

Toy Simulators and Git

A variety of modeling methods will be explored during the class (Monte-Carlo, Molecular Dynamics and Finite Difference are the primary ones.) Matlab code presenting "toy" simulators used to illustrate these methods is in the git repository at 4700Code. For some of the PA sessions you will be modifying this code.

Students must create a github account and use it for their assignments and PA sessions. For PA's you will use this account to download (clone) the course repo's for modification and to upload your own code. For the assignments you should use git locally to maintain a commit history and then when the assignment is due you should upload the repo to your account for marking.
Note: your account is **open**. If you upload your assignment code onto github before the due date your fellow students have access to it. So if you do not want to provide this access only create the repo on github when it is due. **Although collaboration is encouraged mindless copying is not! So learning from others is good, but write your own code!**

Course outline

Tuesday class is in ME 3174. Wednesday and Thursday PA/Labs are in Minto 6030

Week 1 - Modeling Introduction and Source Version Control (Git)

1. Jan. 8 (Tues): Modeling Approaches : (Rules, equations and fields. Analytical versus Numerical. What to Model? MD and Monte Carlo. Differential Eq.) Slides
2. Jan. 9: PA-1 Matlab review and help Instructions
3. Jan 10: Lab-1 - Git Introduction Instructions Aaron's git guide GitHub Guides GitHub Help

Assignment 1: For your write up it should be a little bit more like a lab report than an assignment. Not just a set of simple answers, but also some discussion. Think of it as an numerical experiment.

It is due on Sunday Feb 3rd at 23:59.

There will be workshops in weeks 2-4. At these workshops you show something and you can get help! Assignment 1 Assignment Guidelines Matlab Publishing

Week 2 - Molecular Dynamics modeling

4. Jan. 15: Atomic structure, Bonding and Molecular Dynamics (Kasap (1.1- 1.8)) Slides Code in Git Repo
5. Jan. 16: PA-2 - MD Code Instructions
6. Jan. 17: Lab-2 - Assignment 1

Week 3 - Monte-Carlo Modeling

7. Jan. 22: Kinetic Theory and Monte-Carlo (Kasap (1.1- 1.8)) Slides Code in Git Repo
8. Jan. 25: PA-3 1D electron scattering and resistance Instructions.
9. Jan. 26: Lab-3 Assignment 1

Assignment 2: This assignment deals with solving a PDE (Laplace's Eq) with Finite Difference. A primary point is the limits of both numerical and analytical methods of solution. So you should think of it as a numerical experiment/lab.

It is due on Sunday Feb. 24th at 23:59.

There will be workshops in weeks 5 and 6. At these workshops you show something and you can get help! Assignment 2 Assignment Guidelines

Week 4 - Conduction, Electrostatics, SS Diffusion (iteration)

10. Jan. 29: Conduction, Classical Solids, electrons, drift, resistance, hall effect, non-metals) Slides Code in Git Repo
11. Jan. 30: PA-4 - Laplace equation by iterationInstructions
12. Jan. 31: Lab-4: Assignment 1 or 2

Week 5 - Matrices and Diffusion, Harmonic Wave Equation, Eigenvalues and Modes (QM-SCE)

13. Feb. 5: Quantum Mechanics and Waves PPT Slides Code in Git Repo
14. Feb. 6: PA-5 Implicit solutions and modes Instructions
15. Feb. 7: Lab-5: PA-5/Assignment 2

Week 6 - Time Domain Simulation - Transport and differential equations

16. Feb. 12: Canceled due to Snowflakes
17. Feb. 13: Canceled due to Snowflakes
18. Feb. 14: Assignment 2

Week 7 - Reading Week

Assignment 3: This assignment first modifies your MC code from the 1st assignment to add an electric field. Then it should use your FD code to calculate and electric field for use in your MC code. If your FD code was not as good as it should be I can provide a matlab function that can be used.

It is due on the March 17th Sunday at 23:59.

There will be workshops on weeks 8-10. At this workshop you show something and you can get help! Assignment 3

Week 6 for real - Time Domain Simulation - Transport and differential equations

19. Feb. 26: Transport and continuity equations (Kasap (5.1-5.6)) Slides Code in Git Repo
20. Feb. 27: PA-6 Transport code modification Instructions
21. Feb. 28: Assignment 3

Week 8 - ElectroMagnetic Simulation - waveguide propagation and scattering (modes)

22. March 5: EM - Yee Cell, Waveguides and z propagation PPT Slides
23. March 6: PA-7 Ridge waveguides Instructions Mode Solver Code Mode Solver Paper
24. March 7: Lab-6: Assignment 3

Week 9 ElectroMagnetic Simulation (Yee Cell FDFD/FDTD)

25. March 12: Yee Cell Lecture Slides
26. March 13: PA-8 Yee Cell code modification Instructions Yee Cell Code
27. March 14: Lab-6 Assignment 3

Week 10 - Circuit modeling and compact models

28. March 19: MNA and Compact modeling : (MNA formulation. Physical and non Physical compact models. Neural Nets. Convergence and robustness) Slides
29. March 20 PA-9: MNA Building Instructions
30. March 21: Lab-7 Assignment 4

Assignment 4: In this assignment you will create a very simple circuit simulator implementing time integration using FD and also use Monte-Carlo techniques to simulate noise in a resistor.

It is due on the April 7th Sunday at 23:59.

There will be workshop on weeks 11 and 12. At this workshop you show something and you can get help! Assignment 4

Week 11 -- Device Models (Diodes/BJT/MOSFET)

31. March 26: Diodes, BJT and Mosfet device theory and compact modeling - Kasap (6.1-6.8) Slides
32. March 27: PA-10 Device Compact Models Instructions
33. March 28: Lab-8 Assignment 4

Week 12: Optical circuits and devices

34. April 2: LEDs, Lasers and Optical circuit simulation: Slides
35. April 4: Assignment 4
36. April 5: Review and Final Preparation Slides Final 2016

Week 13 (not happening): Review and Presentations

37. April 2: Review and Final Preparation Slides
38. April 4: Presentations, A Review.
39. April 6: Assignment 4

Academic Accommodation You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows: Pregnancy obligation: write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website http://www2.carleton.ca/equity/accommodation/ Religious obligation: write to me with any requests for

academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website http://www2.carleton.ca/equity/accommodation/ Students with disabilities requiring academic accommodations in this course must register with the Paul Menton Centre for Students with Disabilities (PMC) for a formal evaluation of disability-related needs. Documented disabilities could include but are not limited to mobility/physical impairments, specific Learning Disabilities (LD), psychiatric/psychological disabilities, sensory disabilities, Attention Deficit Hyperactivity Disorder (ADHD), and chronic medical conditions. Registered PMC students are required to contact the PMC, 613-520-6608, every term to ensure that I receive your Letter of Accommodation, no later than two weeks before the first assignment is due or the first in-class test/midterm requiring accommodations. If you only require accommodations for your formally scheduled exam(s) in this course, please submit your request for accommodations to PMC by the deadlines published on the PMC website: http://www2.carleton.ca/pmc/new- and-current-students/dates-and-deadlines/