ECE 740
Semiconductor Device Theory and Modelling

COURSE OUTLINE
Please refer to course website for updated information.

CALENDAR DESCRIPTION

This course provides a fundamental in-depth knowledge of the theory of operation, modeling, parameter extraction, scaling issues, and higher order effects of active and passive semiconductor devices that are used in mainstream semiconductor technology and emerging devices of practical interest. There will be a comprehensive review of the theories and latest models for the devices that are valid out to very high frequencies and the use of physical device modeling. A review of the latest device technologies and architectures will be presented. The course will be a prerequisite to the other applied courses in microelectronics and photonics.

SCHEDULE And MODE Of DELIVERY

The material for this course will be delivered through a mixture of online videos, textbook readings, live online lectures and tutorials (which are also recorded), and virtualized laboratories and projects. The platform for each component is noted at the end of each line.

Lecture: Wednesdays 6:00 p.m. – 9:00 p.m.

INSTRUCTOR

Yaser M. Haddara
Email: yaser@mcmaster.ca
Office: ITB-A223
Office Hours: Tuesdays 3:00 – 5:00 p.m.

COURSE WEBSITE/S

http://avenue.mcmaster.ca

COURSE OBJECTIVES

By the end of this course, students should be able to:
• Recognize Bravais lattices and crystal structures, perform basic calculations related to them, and use Miller’s indices
- Explain the basic concepts and postulates of quantum mechanics and apply quantum mechanics to simple idealized systems
- Explain the basics of the quantum theory of solids, the difference between metals, insulators, and semiconductors, and construct and interpret band diagrams as a function of position
- Compute quantities related to carrier statistics in semiconductors
- Apply transport models to semiconductor devices
- Explain the basic physics of diodes, MOSFETs, and BJTs

ASSUMED KNOWLEDGE

Newton’s laws of motion; basic electromagnetics; terminal characteristics of semiconductors; undergraduate level calculus and linear algebra

COURSE MATERIALS

Textbooks:


References:

Device simulators and manuals – Synopsis, Silvaco, TMA etc..
### COURSE OVERVIEW

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<thead>
<tr>
<th>Week</th>
<th>Topic</th>
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<tbody>
<tr>
<td>1</td>
<td>Introduction to crystallography</td>
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<td>2</td>
<td>Introduction to quantum mechanics</td>
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<td>3</td>
<td>Introduction to quantum theory of solids</td>
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<td>4</td>
<td>Carrier statistics</td>
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<td>5</td>
<td>Carrier transport</td>
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<td>6</td>
<td>PN junctions at equilibrium</td>
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<td>7</td>
<td>PN junctions under bias</td>
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<td>8</td>
<td>The MOS capacitor</td>
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<td>9</td>
<td>MOSFETs theory and modelling</td>
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<td>10</td>
<td>MOSFET second order effects and reliability</td>
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<td>11</td>
<td>BJTs theory and modelling</td>
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<tr>
<td>12</td>
<td>Student presentations</td>
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<tr>
<td>13</td>
<td>Student presentations</td>
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At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

### ASSESSMENT

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
<th>Due Date</th>
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<tbody>
<tr>
<td>In-class exercises</td>
<td>30 %</td>
<td>Ongoing</td>
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<tr>
<td>Project presentation</td>
<td>25%</td>
<td>November 29</td>
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<tr>
<td>Project final paper</td>
<td>25 %</td>
<td>December 17</td>
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<tr>
<td>Final Exam</td>
<td>20 %</td>
<td>TBD</td>
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**Total** 100 %

Late submissions of assignments or project report are subject to 20% penalty per day (less than one day is counted as one day).

### CONDUCT EXPECTATIONS

As a McMaster graduate student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the [Code of Student Rights & Responsibilities](#) (the “Code”). All students share the responsibility of maintaining a positive
environment for the academic and personal growth of all McMaster community members, **whether in person or online.**

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students’ access to these platforms.

**COPYRIGHT AND RECORDING**

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors.

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

**ACADEMIC ACCOMMODATIONS OF STUDENTS WITH DISABILITIES**

Students with disabilities who require academic accommodation must contact **Student Accessibility Services** (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University’s **Academic Accommodation of Students with Disabilities** policy.

**ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)**

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the **RISO** policy. Students should submit their request to their Faculty Office **normally within 10 working days** of the beginning of term in which they anticipate a need for accommodation or to the Registrar’s Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

**EXTREME CIRCUMSTANCES**

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be
communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

**RESEARCH ETHICS**

The two principles underlying integrity in research in a university setting are these: a researcher must be honest in proposing, seeking support for, conducting, and reporting research; a researcher must respect the rights of others in these activities. Any departure from these principles will diminish the integrity of the research enterprise. This policy applies to all those conducting research at or under the aegis of McMaster University. It is incumbent upon all members of the university community to practice and to promote ethical behaviour. To see the Policy on Research Ethics at McMaster University, please go to [http://www.mcmaster.ca/policy/faculty/Conduct/ResearchEthicsPolicy.pdf](http://www.mcmaster.ca/policy/faculty/Conduct/ResearchEthicsPolicy.pdf).

www.eng.mcmaster.ca/ece