

# ECE 331: Advanced Electronic Device Physics

## Fall 2021

### Course Outline

#### Course description

The course reviews and extends the understanding of semiconductor devices operation. Advanced topics and non-ideal characteristics of the pn-junction, metal-semiconductor contacts, MOS capacitor, MOSFET, and BJT will be covered. The topics presented are an extension of the introductory undergraduate device physics course ECE 231.

#### Instructor

William S. Wong, Department of Electrical and Computer Engineering

*Office:* Contact will be available through online meetings and forums (MS Teams, Piazza and e-mail)

*Email:* [wswong@uwaterloo.ca](mailto:wswong@uwaterloo.ca)

*Phone:* ext. 31121

*Office Hours:* TBD

#### Textbook (required)

Donald Neamen, *Semiconductor Physics and Devices*, 4<sup>th</sup> Ed, McGraw-Hill (2011)

Digital copies for purchase and subscriptions are available here:

<https://uwaterloo-store.vitalsource.com/products/semiconductor-physics-and-devices-neamen-donald-v0077418840>

More information may be found on BookLook at the University Book Store website:

<https://wstore.uwaterloo.ca/course-materials/my-booklook.html>

#### Course website

LEARN, ECE 331

#### Lectures

Online Videos and MS Teams Q&A Sessions (TBA)

- Original On-campus Lectures: 1:30 – 2:50 PM on Monday & Friday (TBA)
- Tentatively, online will Q&A sessions will be held on Monday and tutorials on Friday. (TBA)

## **Tutorials**

Online Tutorials

*Tutorials begin the first week of the term.*

## **Labs**

Room E2 – 3347

- *Section 241*: Online video description. Experimental data will be handed out for analysis and discussion in lab reports. Lab reports will be due the week following a lab assignment.
- *Section 242*: Online video description. Experimental data will be handed out for analysis and discussion in lab reports. Lab reports will be due the week following a lab assignment.
- *Section 243*: Online video description. Experimental data will be handed out for analysis and discussion in lab reports. Lab reports will be due the week following a lab assignment.

For lab policies, please see the “Lab Information” document posted on the course website.

## **Teaching Assistants**

TBD

*Email*: TBD

*Office*: Contact will be available through online meetings and forums (MS Teams, Piazza and e-mail)

OH: Online office hours will be announced

## **Lab Instructor**

TBD

*Email*: TBD

*Office*: Contact will be available through online meetings and forums (MS Teams, Piazza and e-mail)

## Tentative Course Outline

- Review of semiconductor materials [Chapters 5 and 6]
  - Carrier transport [Chapter 5]
  - Non-equilibrium Semiconductors and Excess carriers [Chapter 6]
- Device Fabrication Techniques Overview
- p-n junction diodes [Chapter 8]
  - Review of pn junction I-V characteristics
  - Non-uniformly doped pn junctions and charge storage and transients
- Metal-Semiconductor Junctions (Chapter 9)
  - Review of Schottky Barrier contact
  - Non-ideal effects on barrier height
  - M-S Ohmic Contacts
- Metal-oxide-semiconductor field effect transistors (MOSFETs) [Chapter 10]
  - Review of MOS Cap and MOSFET
  - Derivation of I-V Characteristics (mathematical)
  - Frequency Limitations
  - CMOS Technology
  - Non-ideal MOSFET Effects
  - MOSFET Scaling
  - Threshold Voltage Modification
- Bipolar-junction Transistors [Chapter 12]
  - Review of BJT Operation
  - Equivalent Circuit Models
  - Frequency Limitations
  - Large Signal Switching
- Applications LEDs, photodetectors, solar cells [Chapter 14]

## Evaluation

Labs (*20% of total grade*) 20% for five lab reports. Each lab report is worth 4 % of the overall grade; due dates are in the General Lab Information Document on LEARN.

Quizzes (*20% of total grade*) There will be two quizzes worth 10% of the total grade each; quizzes will be online and multiple choice. Tentative quiz dates: Quiz #1 – February 10, 2021 and Quiz # 2 – March 31, 2021. Quizzes are multiple choice with 45-minute time frame once started.

Midterm Exam (*30% of total grade*) – The exam will be given during the midterm week schedule. The exam will have a 75-minute time frame when started within a 24-hour window.

Final Exam (*30% of total grade*) – The exam will be given during the final exam week schedule. The exam will have a 75-minute time frame when started within a 24-hour window.

- There will be two quizzes. The first quiz will be assigned between the start of the course and the midterm, and the second quiz will be assigned between the midterm and the end of the course.
- Quizzes, midterm and final exam will open textbook, open PowerPoint slides, video lectures, and laboratory manuals. No other information is to be used for the graded exams and quizzes.
- Problem sets will be assigned approximately every week, are not handed in or graded, and will be discussed in the tutorial. Solutions will be posted on the website.
- The instructor reserves the right to use alternative grading schemes in special circumstances. For example, if an accommodation or a graded exam is missed, an alternative grading scheme may be used.

### **Required Statements**

**Academic Integrity:** To maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check [www.uwaterloo.ca/academicintegrity/](http://www.uwaterloo.ca/academicintegrity/) for more information.]

**Grievance:** A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance.

Read Policy 70, Student Petitions and Grievances, Section

[www.adm.uwaterloo.ca/infosec/Policies/policy70.htm](http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm). When in doubt please be certain to contact the department's administrative assistant who will provide further assistance.

**Discipline:** A student is expected to know what constitutes academic integrity [check [www.uwaterloo.ca/academicintegrity/](http://www.uwaterloo.ca/academicintegrity/)] to avoid committing an academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline, [www.adm.uwaterloo.ca/infosec/Policies/policy71.htm](http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm). For typical penalties check Guidelines for the Assessment of Penalties, [www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm](http://www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm).

**Appeals:** A decision made or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) [www.adm.uwaterloo.ca/infosec/Policies/policy72.htm](http://www.adm.uwaterloo.ca/infosec/Policies/policy72.htm).

**Note for Students with Disabilities:** The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term.

**Fair Contingencies for Emergency Remote Teaching:** We are facing unusual and challenging times. To provide contingency for unforeseen circumstances, the instructor reserves the right to modify course topics and/or assessments and/or weight and/or deadlines with due notice to students. In the event of

further challenges, the instructor will work with the Department/Faculty to find reasonable and fair solutions that respect rights and workloads of students, staff, and faculty.

**Online Academic Integrity (include in syllabus and assessments):** All students are expected to work individually and submit their own original work. Under Policy 71, the instructor may have follow-up conversations with individual students to ensure that the work submitted was completed on their own. Any follow up will be conducted remotely (e.g., MS Teams, Skype, phone), as the University of Waterloo has suspended all in-person meetings until further notice.