# ENGG*3450 ELECTRICAL DEVICES

## FALL 2014

UNIVERSITY
*of* GUELPH

School of Engineering

(Revision 1: 2 September 2014)

# 1 INSTRUCTIONAL SUPPORT

## 1.1 Instructor

| | |
|---|---|
| Instructor: | Stefano Gregori |
| Office: | RICH 3521, ext. 56191 |
| Email: | sgregori@uoguelph.ca* |
| Office hours: | Posted on the course webpage or by appointment. |

## 1.2 Lecturer

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|---|---|
| Lecturer: | Omar Ahmed |
| Office: | THRN 2401, ext. 58973 |
| Email: | oahmed@uoguelph.ca* |
| Office hours: | Posted on the course webpage or by appointment. |

## 1.3 Laboratory technician

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|---|---|
| Technician: | Hong Ma |
| Office: | RICH 1506, ext. 53873 |
| Email: | hongma@uoguelph.ca* |

## 1.4 Teaching assistants

| GTA | Office | Email | Office hours |
|---|---|---|---|
| Rekha Albert Dhayakaran | THRN 2105 | ralbertd@uoguelph.ca* | on the course webpage |
| Ahmed El Samman | THRN 3116 | aelsamma@uoguelph.ca* | on the course webpage |
| Yin Li | THRN 3116 | yli18@uoguelph.ca* | on the course webpage |
| He Ma | THRN 3116 | hma02@uoguelph.ca* | on the course webpage |
| Tulasi Marini | THRN 2106 | tmarini@uoguelph.ca* | on the course webpage |
| Abu Siddique | TBA | asiddi04@uoguelph.ca* | on the course webpage |
| Ahmed Shaltout | THRN 3116 | ashaltou@uoguelph.ca* | on the course webpage |

*Please use the course address engg3450@uoguelph.ca for teaching purposes. Please use individual addresses for non-teaching purposes only (e.g. setting up an appointment time).

# 2 Learning resources

## 2.1 Course website

Please check the course webpage on CourseLink regularly for information and materials.

## 2.2 Required resources

Textbook:

- A. S. Sedra, K. C. Smith, *Microelectronic circuits*, Oxford, 6th ed., 2009.

## 2.3 Recommended resources

Reference books for consultation:

- D. A. Neamen, *Microelectronics: circuit analysis and design*, McGraw-Hill, 4th ed., 2010.
- R. L. Boylestad, L. Nashelsky, *Electronic devices and circuit theory*, Prentice Hall, 11th ed., 2013.

The textbook and the reference books above are available on Course Reserve in the library.

## 2.4 Additional resources

Additional references are indexed by library call numbers TK7800 to TK8360.

## 2.5 Communication and email policy

Communication is through announcements in class. Some information will be posted on the course web page or sent via email messages to your University address. It is your responsibility to keep yourself informed about the course.

Please use lectures, tutorials, and laboratory sessions as your main opportunity to ask questions about the course. Please meet the instructor and the teaching assistants during the posted office hours when you have specific questions about course concepts, laboratory experiments, and problem sets and any question that cannot be answered easily or briefly with a reply email.

The email policy is as follows:

- Use your University email account for correspondence relating to the course.
- Send your emails to the course address engg3450@uoguelph.ca. You will normally receive a reply in a timely manner (with the exception of nights, weekends, and holidays). If you do not receive a reply within two days, please resubmit your question or phone (leave a message if necessary).
- Include a subject header with the topic of your message (e.g. "Ch 1 question," "Lab 2 question for the GTA," "missed midterm"), a clearly written message, and your name and student number.
- Use individual addresses for non-teaching purposes only (e.g. setting up an appointment time) and add the course identifier "ENGG*3450" to the subject header.

The University regulations require all students to check regularly their University email accounts, because email is the official route of communication between the University and its students.

# 3 ASSESSMENT

## 3.1 Dates and distribution

**Laboratories** (*L*)**:** from 0 to 40 points, made of four laboratory reports (0 to 7.5 points each) plus a laboratory test (0 to 10 points). Please see section 5.3 for schedule and due dates.

**Midterm exam** (*M*)**:** from 0 to 20 points. The midterm exam is scheduled on Friday, 17 October 2014, 10:30 to 11:20, in THRN 1200.

**Final exam** (*F*)**:** from 0 to 40 points. The final exam is scheduled on Monday, 1 December 2014, 14:30 to 16:30, please verify time and location on WebAdvisor.

**Final grade** (*G*)**:** from 0 to 100%. The pass grade is 50%.
The final grade *G* is calculated based on the premises that you must pass the exams in order to pass the course (i.e. you must have $M + F \geq 30$) and that, if you do better in the final than in the midterm exam, the final will have a higher weighting.
Setting
$$E = \max\left(F + M, \tfrac{6}{5}F + \tfrac{3}{5}M\right),$$
your final grade in percentage points is given by
$$G = E + \frac{L}{1 + e^{30 - E}}.$$

## 3.2 Course grading policies

**Missed assessments:** If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please email the course instructor at the earliest possible time. Please see the undergraduate calendar for information on regulations and procedures for academic consideration: http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

**Accommodation of religious obligations:** If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester or at the earliest possible time. Please see the undergraduate calendar for information on regulations and procedures for academic consideration of religious obligations:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

**Missed exams:** Any student not taking an exam receives a grade of zero for that exam. There are no makeup midterm exams. In case you have a legitimate reason for missing an exam, the instructor may consider an accommodation upon presentation of a written request and suitable documentation before the time of the exam.

**Laboratory work:** You must attend and complete all laboratories and take the laboratory test. There are no makeup laboratory tests. In case you have a legitimate reason for missing a laboratory or test, the instructor may consider an accommodation upon presentation of a written request and suitable documentation before the time of the laboratory or test.

**Late laboratory reports:** Any student not handing in a report receives a grade of zero for that submission. There are no makeup reports and late submissions are not accepted for marking.

**Copies of reports:** Please keep back-up copies of all out-of-class assignments, because you may be asked to resubmit your work.

# 4 AIMS, OBJECTIVES AND GRADUATE ATTRIBUTES

## 4.1 Calendar description

Semiconductors materials, Silicon, Germanium and other semi-conductors' material, Doping and effects of extrinsic material introduction, conduction in metals and semi-conductors, electrical and thermal characteristics of diodes and transistors; principles of modern electronic devices and their applications in circuits; diodes; bipolar and field effect transistors; circuit integration; operational amplifiers; logic gates. *Prerequisite(s):* ENGG*2450

## 4.2 Course aims

This course aims at:

1. Understanding of the properties of semiconductor materials and their use in microelectronic circuits.

2. Learning about diode and transistor models and operation.

3. Analyzing and designing basic electronic circuit applications.

4. Connecting device-level to circuit-level performance of microelectronic systems.

## 4.3 Learning objectives

After successfully completing the course you will be able to:

1. Relate the properties of semiconductor materials to the models of diodes and transistors.

2. Describe the principles of operation of diodes and transistors.

3. Apply device models and execute mathematical operations in order to solve circuit problems using the large-signal and small-signal abstractions.

4. Analyse and evaluate the performance of circuits with diodes, transistors, operational amplifiers, and logic gates.

5. Identify the device parameters that determine function and performance of amplifier building blocks, operational amplifiers, and logic gates.

6. Operate basic electronic instrumentation and communicate about data sheets of electronic devices and integrated circuits.

7. Characterize electronic devices and assemble and troubleshoot simple circuits.

## 4.4 Graduate attributes

Successfully completing this course will contribute to the following CEAB graduate attributes:

| Graduate attributes | Learning objectives | Assessment |
|---|:---:|:---:|
| 1. A knowledge base for engineering | 1, 2, 3 | reports, exams |
| 2. Problem analysis | 3, 4 | reports, exams |
| 3. Investigation | 3, 4, 6, 7 | reports |
| 4. Design | 4, 5, 7 | reports |
| 5. Use of engineering tools | 6 | reports |
| 6. Communication skills | 3, 6 | reports, exams |
| 7. Individual and team work | 6, 7 | reports |
| 8. Professionalism | All | reports, exams |
| 9. Impact of engineering on society and the environment | All | reports, exams |
| 10. Ethics and equity | All | reports, exams |
| 11. Economics and project management | 6, 7 | reports |
| 12. Life-long learning | All | reports, exams |

## 4.5    Instructor's role and responsibility to students

The instructor's role is to develop and deliver course material in ways that facilitate learning for a variety of students. The lecture notes and materials available to students on the course web site are not intended to be a stand-alone course. During the lectures, the instructor expands and explains the course contents and provides example problems that supplement notes and textbook. Scheduled classes and laboratory sessions are the principal venue to provide information and feedback about exams and laboratories.

## 4.6    Students' learning responsibilities

Students are encouraged to take advantage of all the learning opportunities provided by lectures, tutorials, and laboratory sessions. Students, especially those having difficulty with the course content, should also make use of additional resources recommended by the instructor and by tutorials and study sessions. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This allows the instructor to recommend extra resources in a timely manner and provide consideration if appropriate.

You are encouraged to spread the learning periods over the entire semester. Start studying from today without postponement. You should try to avoid distractions while studying and during lectures, tutorials, and laboratory sessions. Take down notes and outlines while reading or listening. Note down the questions and doubts that arise and get clarifications immediately. When you are in the classroom, as a courtesy to classmates and instructors, please keep your cell phone silenced, do not eat (water or a drink in a leak-proof container are fine in the classroom), and use your tablet or laptop only for note-taking or course-related applications.

## 4.7    Relationships with other courses

**Previous courses:**

    **ENGG*2450:** Electric Circuits, lumped-element models, circuit analysis, linearity and superposition, circuit theorems, operational amplifier, RLC circuits.

**Follow-on courses:**

    **ENGG*3050:** Embedded Reconfigurable Computing Systems, analysis and design of embedded systems based on field programmable gate arrays.

**ENGG*3490:** Introduction to Mechatronic Systems Design, modelling and design of mechatronic systems with electronic and mechanical components.

**ENGG*4080:** Micro and Nano-Scale Electronics, circuit integration and operating principles of analog integrated micro and nano electronic circuits.

**ENGG*4390:** Bio-Instrumentation Design, electronic instrumentation and measurements for biological systems.

**ENGG*4550:** VLSI Digital Design, static and dynamic CMOS gates, latches, registers, pipelining, adders, multipliers, shifters.

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# 5 TEACHING AND LEARNING ACTIVITIES

## 5.1 Timetable

**Lectures:**

| | | |
|---|---|---|
| Monday | 10:30 to 11:20 | THRN 1200 |
| Wednesday | 10:30 to 11:20 | THRN 1200 |
| Friday | 10:30 to 11:20 | THRN 1200 |

**Laboratory sessions and tutorials:**

| | | |
|---|---|---|
| Monday | 15:30 to 17:20 | RICH 1504 |
| Wednesday | 15:30 to 17:20 | RICH 1504 |
| Thursday | 12:30 to 14:20 | RICH 1504 |
| Friday | 15:30 to 17:20 | RICH 1504 |

## 5.2 Lecture schedule

| W | Dates | Lecture topics | References | Learning objectives |
|---|---|---|---|---|
| 0 | Sep-04 to Sep-05 | Introduction and basic concepts | Ch 1 | 1 |
| 1 | Sep-08 to Sep-12 | Semiconductors and pn junction | Ch 3 | 1, 2 |
| 2 | Sep-15 to Sep-19 | Diodes | Ch 4 | 1, 2 |
| 3 | Sep-22 to Sep-26 | MOSFET transistors | Ch 5 | 1, 2, 4 |
| 4 | Sep-29 to Oct-03 | MOSFET and BJT transistors | Ch 5, 6 | 3, 4 |
| 5 | Oct-06 to Oct-10 | Amplifier building blocks | Ch 7 | 3, 4 |
| 6 | Oct-13 to Oct-17 | Differential stages | Ch 8 | 3, 4 |
| 7 | Oct-20 to Oct-24 | Operational amplifiers | Ch 2, 12 | 3, 4 |
| 8 | Oct-27 to Oct-31 | Operational amplifiers | Ch 9 | 3, 5 |
| 9 | Nov-03 to Nov-07 | Inverters | Ch 13 | 4, 5 |
| 10 | Nov-10 to Nov-14 | Logic gates | Ch 13 | 4, 5 |
| 11 | Nov-17 to Nov-21 | Advanced topics | Ch 12, 13 | 3, 4, 5 |
| 12 | Nov-24 to Nov-28 | Review | All | 1 to 5 |

Topics schedule will be adjusted throughout the course as needed.

## 5.3   Laboratory and tutorial schedule

| W | Dates | Topics | Due |
|---|---|---|---|
| 0 | Sep-04 to Sep-05 | — | — |
| 1 | Sep-08 to Sep-12 | Laboratory 1 | — |
| 2 | Sep-15 to Sep-19 | Laboratory 2 | Sep-26 |
| 3 | Sep-22 to Sep-26 | Tutorial 1 | — |
| 4 | Sep-29 to Oct-03 | Laboratory 3 | Oct-10 |
| 5 | Oct-06 to Oct-10 | Tutorial 2 | — |
| 6 | Oct-13 to Oct-17 | — | — |
| 7 | Oct-20 to Oct-24 | Laboratory 4 | Oct-31 |
| 8 | Oct-27 to Oct-31 | Tutorial 3 | — |
| 9 | Nov-03 to Nov-07 | Laboratory 5 | Nov-14 |
| 10 | Nov-10 to Nov-14 | Tutorial 4 | — |
| 11 | Nov-17 to Nov-21 | Laboratory exam | — |
| 12 | Nov-24 to Nov-28 | — | — |

## 5.4   Other important dates

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| Thursday, 4 September 2014: | First day of class |
| Monday, 13 October 2014: | Holiday (i.e. no classes scheduled) |
| Tuesday, 14 October 2014: | Study break day (i.e. no classes scheduled) |
| Friday, 31 October 2014: | Fortieth class day (i.e. drop date) |
| Thursday, 27 November 2014: | Tuesday schedule in effect |
| Friday, 28 November 2014: | Monday schedule in effect and last day of class |

Please consult the Undergraduate Calendar to verify the schedule of dates for this term:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c03/c03-fallsem.shtml
Please consult the Undergraduate Calendar to find information about dropping courses:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

## 5.5   Obtaining help

You can obtain help from the instructor and the teaching assistants during the office hours (posted on the course web page) and from the laboratory technician during the laboratory time slots.

Please contact the instructor if you need help or you have fallen behind in your work. He is willing to put in as much effort to help you as you are willing to put in to help yourself. He is happy to work with you on difficult concepts and hear your suggestions for improving the course. If you are busy during his office hours, then email him with some days and times you are free, and he will set an appointment that works for both you and him.

If you are ill, please call the Student Health Services or a medical doctor. If you have emotional, family, or living environment problems that affect your ability to study, please visit the Counselling Services or your academic advisor. If you have a disability or a short-term disability, please refer to the Centre for Students with Disabilities. You are encouraged to use the available services and programs and you are welcome to discuss with the instructor your specific learning needs in this course at the earliest possible time.

# 6 LABORATORY SAFETY

Safety is critically important to the School of Engineering and is a shared responsibility among faculty, staff, and students. As a student you are responsible for taking all reasonable safety precautions and following the approved safety procedures specific to the laboratory you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor or the faculty responsible.

Please use good judgement and safe working habits and remember that food and drink are not allowed in laboratories. Before the first laboratory session, you must read the manual on Safety and Laboratory Policies and complete the safety quiz on the course webpage. In case of doubts about safety procedures please consult with the laboratory technician or the instructor before proceeding. Any violation of safety policies may result in loss of laboratory privileges.

# 7 ACADEMIC MISCONDUCT

The University of Guelph is committed to upholding the highest standards of academic integrity and it is the responsibility of all members of the University community faculty, staff, and students to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff and students have the responsibility of supporting an environment that discourages misconduct. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried submission of assignments does not excuse you from the responsibility for verifying the academic integrity of your work before submitting it. If you are in any doubt as to whether an action on your part could be construed as an academic offence, you should consult with a faculty member.

## 7.1 Resources

The Academic Misconduct Policy is detailed in the Undergraduate Calendar:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

A tutorial on Academic Integrity produced by the Learning Commons can be found at:
http://www.academicintegrity.uoguelph.ca/

Please also review the section on Academic Misconduct in your Engineering Program Guide.

The School of Engineering has adopted a Code of Ethics that can be found at:
http://www.uoguelph.ca/engineering/undergrad-counselling-ethics

## 7.2 Recommendations

You are encouraged to familiarize yourself with your responsibilities, review the tutorial on Academic Integrity, and discuss any question you may have with the instructor or a faculty member.

When writing laboratory and project reports, please remember that copying text, data, or figures is plagiarism, even if you received the material from a friend or you found it on the internet. Letting others use your work is also not allowed. Therefore please keep your reports and data in a secure location.

# 8 ACCESSIBILITY

The University of Guelph is committed to creating a barrier-free environment. Providing services for students is a shared responsibility among students, faculty and administrators. This relationship is based on respect of individual rights, the dignity of the individual and the University community's shared commitment to an open and supportive learning environment. Students requiring service or accommodation, whether due to an identified, ongoing disability or a short-term disability should contact the Centre for Students with Disabilities as soon as possible.

For more information, please contact the Centre for Students with Disabilities at ext. 56208 or email csd@uoguelph.ca or see the website: http://www.uoguelph.ca/csd

# 9 RECORDING OF MATERIALS

Presentations which are made in relation to course work, including lectures, tutorials, and laboratory sessions, cannot be recorded or copied without prior permission of the presenter, whether the instructor, a classmate or guest lecturer. Material recorded with permission is restricted to use for this course unless further permission is granted.

The instructor reserves the right to all materials made available for this course and all interpretations presented in class, which may not be reproduced or transmitted to others without the written consent of the instructor. The materials available on the course web page may be protected by copyright and are only for the use of students enrolled in this course for the purposes associated with this course and may not be retained or further disseminated.

# 10 RESOURCES

The Academic Calendars are the source of information about the University of Guelph's procedures, policies and regulations which apply to undergraduate, graduate and diploma programs.

This course outline includes sections and standard statements adapted with permission from the course outline template of the School of Engineering and from the course outline checklist of the University of Guelph. In case of any discrepancy, please refer to the current Academic Calendars.