ENGG*3450 Electrical Devices

Fall 2015

University of Guelph

School of Engineering

(Revision 2: 10 September 2015)

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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 Laboratory technician

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

1.3 Teaching assistants

Teaching assistant	Office	Email	Office hours
Bazyli Debowski	THRN 3112	debowskb@uoguelph.ca	on course webpage or by appointment
Yin Li	THRN 3116	yli18@uoguelph.ca	on course webpage or by appointment
Ahmed Shaltout	THRN 3116	ashaltou@uoguelph.ca	on course webpage or by appointment
Abu Siddique	THRN 3114	asiddi04@uoguelph.ca	on course webpage or by appointment
Mohammad Usman	THRN 3116	usmanm@uoguelph.ca	on course webpage or by appointment

2 LEARNING RESOURCES

2.1 Course webpage

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

2.2 Required resources

Textbook:

- A. S. Sedra, K. C. Smith, *Microelectronic Circuits*, Oxford, 7th ed., 2014. TK7867 .S39

2.3 Recommended resources

Reference books for consultation:

- S. Dimitrijev, *Principles of Semiconductor Devices*, Oxford, 2nd ed., 2011. TK7871.85 .D54697
- D. A. Neamen, *Microelectronics: Circuit Analysis and Design*, McGraw-Hill, 4th ed., 2010. TK7867 .N412

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 webpage 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 receive information about the course. Please meet the instructor and the teaching assistants during the posted office hours when you have specific questions about concepts, problem sets, and laboratory experiments, and any question that cannot be answered easily or briefly with a reply email.

The course email policy is as follows:

- Use your University email account for correspondence relating to the course.
- Start the subject header with the course identifier "ENGG*3450" and add the topic of your message (e.g. "Ch 1 question," "Lab 2 problem," "missed midterm").
- Include a clearly written message and your name and student number.
- 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 (leaving a message if necessary).

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

The course evaluation will be conducted online on https://courseeval.uoguelph.ca/.

3 ASSESSMENT

3.1 Dates and distribution

Laboratories ($L = L_2 + L_3 + L_4 + L_5 + L_t$)**:** from 0 to 40 points, made of four laboratory reports (L_2, 0 to 6 points; L_3, 0 to 7 points; L_4, 0 to 8 points; L_5, 0 to 9 points) and a laboratory test (L_t, 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 on Monday, 26 October 2015, 16:30 to 17:50, in ROZH 103. Please verify time and location on the course webpage.

Final exam (F)**:** from 0 to 40 points. The final exam is on Friday, 18 December 2015, 14:30 to 16:30. Please verify time and location on the exam schedule webpage.

Final grade (G)**:** from 0 to 100%. The pass grade is 50%. The final grade is calculated based on the necessary condition that you must pass the exams in order to pass the course, and on the concept that the final exam will have a higher weighting if you do better in the final than in the midterm. Setting

$$E = \max\left(F + M, \tfrac{6}{5}F + \tfrac{3}{5}M\right),$$

your final grade in percentage points is given by

$$G = E + \frac{L}{1 + \frac{(L-20)\cdot u(L-20)}{20 \cdot e^{(E-30)\cdot u(E-30)}}} \quad \text{with} \quad u(x) = \begin{cases} 0, & x < 0 \\ 1, & x \geq 0 \end{cases} \quad \text{unit step.}$$

3.2 Course grading policies

Missed assessments: If you are unable to meet an in-course requirement because of illness or compassionate reasons, please email the course instructor at the earliest possible time. The regulations and procedures for academic consideration are detailed in the Undergraduate Calendar:
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 at the earliest possible time and within two weeks of the start of the semester. 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 is no laboratory exemption, and there are no makeup laboratory sessions or tests. Attendance is mandatory for submitting laboratory reports. In case you have a legitimate reason for missing a session or test, the instructor may consider an accommodation upon presentation of a written request and suitable documentation before the time of the session 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 reliable 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

This course explores the theory and principles of modern electronic devices and their applications in circuits. Course topics include: intrinsic and doped semiconductors; drift and diffusion currents; metal-semiconductor contacts and MOS capacitors; pn junctions and breakdown phenomena; solid-state diodes; bipolar and MOS field-effect transistors; current-voltage characteristics and dc biasing; small-signal models and operation; circuit integration; analysis and design of application circuits, operational transconductance amplifiers, and logic gates. *Credit weight:* [0.50]. *Prerequisite(s):* ENGG*2450.

4.2 Course aims

This course aims to provide you with:
1. Information about the properties of semiconductor materials and about the models and the principles of operation of electronic devices.
2. Understanding of the connection between device-level and circuit-level performance as a premise to analyzing electronic circuits and designing applications that operate as you desire.
3. Consolidation and development of your knowledge-integration and investigation skills to solve problems in electronics and to prepare for your career in engineering.

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, and describe the principles of operation of these devices.
2. Bias a circuit for linear operation, and solve circuit problems by applying device models and by executing mathematical operations based on the large-signal and small-signal abstractions.
3. Understand that you can use ideal models to predict experiments with real devices, and identify in which aspects the behaviour of a real device deviates from its model.
4. Draw schematic diagrams correctly, and apply systematic analysis methods to evaluate the performance of circuits with diodes, transistors, amplifiers, and logic gates.
5. Read schematic diagrams, deduce function from combination of devices, and identify the device parameters that determine performance of gain stages, amplifiers, and logic gates.
6. Safely operate basic electronic instrumentation for characterizing electronic devices, assemble and troubleshoot simple circuits, and communicate about data sheets of electronic devices.

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	reports, exams
2. Problem analysis	2, 4	reports, exams
3. Investigation	3, 5, 6	reports, lab test
4. Design	4, 5, 6	reports
5. Use of engineering tools	5, 6	reports, lab test
6. Communication skills	4, 5, 6	reports, exams
7. Individual and team work	6	reports
8. Professionalism	4, 5, 6	reports, exams
9. Impact of engineering on society and the environment	3	reports
10. Ethics and equity	all	reports, exams
11. Economics and project management	6	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 webpage 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, tutorials, and laboratory sessions are the principal venues 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 notes and outlines while reading or listening. Note down the questions and doubts that arise and get clarifications at the earliest possible time. 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 and course-related applications.

4.7   Relationships with other courses

Previous courses:

> **ENGG*2450, Electric Circuits:** lumped-element models, node and mesh analysis, linearity and superposition, Thévenin and Norton theorems, operational amplifier, RLC circuits in dc, ac, and transient conditions.

Follow-on courses:

> **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 integrated micro and nano electronic circuits.

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

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

5 TEACHING AND LEARNING ACTIVITIES

5.1 Timetable

Lectures:

Monday	16:30 to 17:20	ROZH 103
Wednesday	16:30 to 17:20	ROZH 103
Friday	16:30 to 17:20	ROZH 103

Laboratory sessions and tutorials:

Sect. 1	Friday	08:30 to 10:20	RICH 1504
Sect. 2	Friday	11:30 to 13:20	RICH 1504
Sect. 3	Friday	13:30 to 15:20	RICH 1504

5.2 Lecture schedule

Week	Dates	Lecture topics	References	Learning objectives
	Sep. 10 to Sep. 11	Introduction and basic concepts	ch. 1	1, 4, 5
1	Sep. 14 to Sep. 18	Semiconductors and pn junction	ch. 3	1
2	Sep. 21 to Sep. 25	Diodes	ch. 4	1, 2
3	Sep. 28 to Oct. 2	Diode circuits	ch. 4	1, 2, 3, 4, 6
4	Oct. 5 to Oct. 9	Transistors	ch. 5	1, 2
5	Oct. 12 to Oct. 16	Transistor circuits	chs. 5, 7	1, 2, 3, 4, 6
6	Oct. 19 to Oct. 23	Amplifier building blocks	chs. 7, 8	2, 3, 4, 5
7	Oct. 26 to Oct. 30	Differential amplifiers	ch. 9	4, 5
8	Nov. 2 to Nov. 6	Differential amplifiers	ch. 9	4, 5, 6
9	Nov. 9 to Nov. 13	Inverters	ch. 14	3, 4, 5
10	Nov. 16 to Nov. 20	Logic gates	ch. 14	4, 5
11	Nov. 23 to Nov. 27	Advanced topics, if schedule permits	chs. 12, 13	3, 4, 5, 6
12	Nov. 30 to Dec. 4	Review	all	1 to 6

Topics schedule will be adjusted throughout the course as needed.

5.3 Laboratory and tutorial schedule

Week	Date	Laboratory and tutorial topics	Due date
	Sep. 11	Tutorial 1, review of essential concepts	—
1	Sep. 18	Laboratory 1, introduction to instruments, components, and laboratory practices	—
2	Sep. 25	Laboratory 2 (L_2), diodes and diode circuits	Oct. 2
3	Oct. 2	Tutorial 2, semiconductors, diodes, and analysis of diode circuits	—
4	Oct. 9	Laboratory 3 (L_3), transistors and transistor circuits	Oct. 16
5	Oct. 16	Tutorial 3, transistors and analysis of transistor circuits	—
6	Oct. 23	Review tutorial	—
7	Oct. 30	Laboratory 4 (L_4), gain stages and differential amplifiers	Nov. 6
8	Nov. 6	Tutorial 4, analysis of amplifier circuits	—
9	Nov. 13	Laboratory 5 (L_5), differential amplifiers and logic gates	Nov. 20
10	Nov. 20	Tutorial 5, analysis of differential amplifiers and logic gate circuits	—
11	Nov. 27	Laboratory test (L_t)	—
12	Dec. 4	Review tutorial, if schedule permits	—

Topics schedule will be adjusted throughout the course as needed.

5.4   Other important dates

Thursday, 10 September 2015:   First day of class
Monday, 12 October 2015:   Holiday (i.e. no classes scheduled)
Tuesday, 13 October 2015:   Study break day (i.e. no classes scheduled)
Friday, 6 November 2015:   Fortieth class day (i.e. drop date)
Thursday, 3 December 2015:   Tuesday schedule in effect
Friday, 4 December 2015:   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 webpage) 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 Student Accessibility Services. 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.

Food and drinks are prohibited from all laboratories. Food is prohibited from all computer rooms and drinks are permitted only if stored in a sealed, reusable container. You are not allowed to let unauthorized people in, or to wedge the doors open.

Please use good judgement and safe working habits and remember that food and drink are not allowed in RICH 1504 at any time. Before the first laboratory session, you must read the course 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 laboratory reports does not excuse you from the responsibility for verifying the 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 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 Student Accessibility Services as soon as possible.

For more information, please contact the Student Accessibility Services at extension 56208, or email csd@uoguelph.ca, or see the webpage: http://www.uoguelph.ca/csd.

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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 teaching assistant, a classmate, or a 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, which may not be reproduced, retained, or transmitted to others without the written consent of the instructor. The materials available on the course webpage 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.

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10 RESOURCES

The Academic Calendars are the source of information about the University of Guelph's procedures, policies and regulations that 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.