ENGG*3450 ELECTRONIC DEVICES

FALL 2017

UNIVERSITY of GUELPH

School of Engineering

(Revision 1: 1 September 2017)

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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
Mark Lipski	THRN —	mlipski@uoguelph.ca	on course webpage or by appointment
You Lyu	THRN 3116	ylyu@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

2 LEARNING RESOURCES

2.1 Required resources

Course webpage

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

Textbook

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

2.2 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

Library resources

The textbook and the reference books above are available in the bookstore and on Course Reserve in the library. Additional references are indexed by library call numbers TK7800 to TK8360 (i.e. located on the 5th floor of the library).

2.3 Additional resources

Lecture notes

The lecture notes will be posted on the course webpage. The notes are prepared with the intention that you will fill in the blanks, take additional notes and write down examples during class.

Problem sets

The problem sets will be posted on the course webpage.

Laboratory manuals

The laboratory manuals will be posted on the course webpage. The manuals are prepared with the intention that you will read them before each laboratory session to be ready for a safe and successful activity.

Datasheets of electronic components

The datasheets of electronic components will be posted on the course webpage.

2.4 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 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.

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3 Assessment

3.1 Dates and distribution

Laboratories (L): from 0 to 30 points, made of three laboratory reports (0 to 10 points each). Please see section 5.3 for the schedule and due dates.

Midterm exam (M): from 0 to 30 points. The midterm exam is on Friday, 27 October 2017, 16:30 to 18:00. Please verify time and location on the course webpage.

Final exam (F): from 0 to 40 points. The final exam is on Saturday, 9 December 2017, 11:30 to 13:30. Please verify time and location on the exam schedule webpage.

Final grade (G): from 0 to 100%. The pass grade is 50%. You must pass the exams (i.e. midterm and final combined) in order to pass the course, and the final exam will have a higher weighting if you do better in the final than in the midterm. Accordingly, your final grade is calculated as follows. Setting

$$E = \max\left(F + M,\, \tfrac{9}{8}F + \tfrac{5}{6}M\right),$$

your final grade in percentage points is given by

$$G = E + \frac{L}{1 + \frac{(L-15)\cdot u(L-15)}{15\cdot e^{(E-35)\cdot u(E-35)}}} \quad \text{with} \quad u(x) = \begin{cases} 0, & x < 0 \\ 1, & x \geq 0 \end{cases} \quad \text{unit step.}$$

3.2 Course grading policies

Missed assessments: If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please advise the course instructor in writing (with your name, student number, and email contact) at the earliest possible time. Please see the undergraduate calendar for

information on regulations and procedures for academic consideration:
https://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 start of the semester to make alternative arrangements. Please see the undergraduate calendar for information on regulations and procedures for academic accommodation of religious obligations:
https://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 the midterm exam, the instructor may consider an accommodation upon presentation of a written request and suitable documentation before the time of the exam.

Laboratory work: There are no laboratory exemptions, and attendance is mandatory for submitting laboratory reports. There are no makeup laboratory sessions. In case you have a legitimate reason for missing a session, the instructor may consider an accommodation upon presentation of a written request and suitable documentation before the time of the session.

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.

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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 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 the connections between device-level characteristics and circuit-level performance as the way to analyzing electronic circuits and designing applications that operate as you desire.
3. Developing your knowledge-integration, problem-solving, and investigation skills to prepare for your career in engineering.

4.3 Learning outcomes

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 bench-top 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	reports, exams
4. Design	4, 5	reports
5. Use of engineering tools	5, 6	reports
6. Communication skills	all	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 participate to 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 term (e.g. it is a good idea to start studying from today). 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 a classroom or laboratory, as a courtesy to classmates and instructors, please keep your cellphone silenced, do not eat (water or a drink in a leak-proof container are usually fine), 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, and shifters.

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5 TEACHING AND LEARNING ACTIVITIES

5.1 Timetable

Lectures

Monday	16:30 to 17:20	ALEX 100
Wednesday	16:30 to 17:20	ALEX 100
Friday	16:30 to 17:20	ALEX 100

Laboratory sessions and tutorials

Sect. 1	Tuesday	10:30 to 12:20	RICH 1504
Sect. 2	Thursday	13:30 to 15:20	RICH 1504
Sect. 3	Tuesday	13:30 to 15:20	RICH 1504

5.2 Lecture schedule

Week	Dates	Lecture topics	References	Learning objectives
—	Sept. 7 to Sept. 8	Introduction and basic concepts	ch. 1	1, 4, 5
1	Sept. 11 to Sept. 15	Semiconductors and pn junction	ch. 3	1
2	Sept. 18 to Sept. 22	Diodes	ch. 4	1, 2
3	Sept. 25 to Sept. 29	Diode circuits	ch. 4	1, 2, 3, 4, 6
4	Oct. 2 to Oct. 6	Transistors	ch. 5	1, 2
5	Oct. 9 to Oct. 13	Transistor circuits in dc	ch. 5	1, 2, 3, 4, 6
6	Oct. 16 to Oct. 20	Transistor amplifiers	ch. 7	2, 3, 4, 5
7	Oct. 23 to Oct. 27	Amplifier building blocks	ch. 8	4, 5
8	Oct. 30 to Nov. 3	Differential and multistage amplifiers	ch. 9	4, 5, 6
9	Nov. 6 to Nov. 10	Inverters	ch. 14	3, 4, 5
10	Nov. 13 to Nov. 17	Logic gates	ch. 14	4, 5
11	Nov. 20 to Nov. 24	Advanced topics, if schedule permits	chs. 6, 13, 15	3, 4, 5, 6
12	Nov. 27 to Dec. 1	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
—	Sept. 7–8	—	—
1	Sept. 11–15	Laboratory 1, instruments, components, and laboratory practices	—
2	Sept. 18–22	Tutorial 1, semiconductors and pn junction	—
3	Sept. 25–29	Laboratory 2, diodes and diode circuits	Oct. 2–6
4	Oct. 2–6	Tutorial 2, diodes and analysis of diode circuits	—
5	Oct. 9–13	Study-break week	—
6	Oct. 16–20	Tutorial 3, transistors and analysis of transistor circuits in dc	—
7	Oct. 23–27	Laboratory 3, transistors and gain stages	Oct. 30–Nov. 3
8	Oct. 30–Nov. 3	Tutorial 4, analysis of amplifier circuits (small-signal abstraction)	—
9	Nov. 6–10	Laboratory 4, transistor amplifiers and logic gates	Nov. 13–17
10	Nov. 13–17	Tutorial 5, analysis of differential amplifiers and logic gate circuits	—
11	Nov. 20–24	Tutorial 6, review	—
12	Nov. 27–Dec. 1	—	—

Topics schedule will be adjusted throughout the course as needed.

5.4 Other important dates

Thursday, 7 September 2017:	First day of class
Monday, 9 October 2017:	Holiday (i.e. no classes scheduled)
Tuesday, 10 October 2017:	Study break day (i.e. no classes scheduled)
Friday, 3 November 2017:	Fortieth class day (i.e. drop date)
Thursday, 30 November 2017:	Tuesday schedule in effect
Friday, 1 December 2017:	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 to 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.

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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. 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.

Please note that whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

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/

A section on Academic Misconduct and the Code of Ethics adopted by the School of Engineering are available in the Rules and Procedures Guide for engineering students.

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.

7.3 Turnitin

In this course, your instructor will be using Turnitin, integrated with the CourseLink Dropbox tool, to detect possible plagiarism, unauthorized collaboration or copying as part of the ongoing efforts to maintain academic integrity at the University of Guelph.

All submitted assignments will be included as source documents in the Turnitin.com reference database solely for the purpose of detecting plagiarism of such papers. Use of the Turnitin.com service is subject to the Usage Policy posted on the Turnitin.com site.

8 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required, however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to book their exams at least seven days in advance, and not later than the fortieth class day.

For more information, please contact the SAS at extension 56208 or email accessibility@uoguelph.ca, or consult the webpage: https://wellness.uoguelph.ca/accessibility/.

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.

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.