Carleton University

Faculty of Engineering, Department of Electronics

ELEC 2507 A/B - Electronic - I

Winter Term 2019

Instructor:

Name	Sections	Office/hours	Email
Prof. Ram Achar	A&B	3036 MC Tue: 1:30pm - 2:30pm Wed: 2:30pm – 3:30pm	achar@doe.carleton.ca

Text Book and Materials:

- *Microelectronic Circuits*, 7th Edition, A. Sedra and K. Smith, Oxford, 2014.
- Course Notes/Handouts

Laboratory Manual: *Electronics – I: Laboratory Manual* and *Lab-Tutorial* & Lab-Tutorial (will be posted on CUlearn Elec2507A/B crosslist portal)

Course Summary and Goals:

This is a first course covering semiconductor devices, their operation, and their application in simple analog electronic circuits. The material in chapters 1-7 of the text will be covered, including qualitative semiconductor physics leading to the diode equation, and diode circuit analysis. Bipolar and MOS transistors are introduced, including design of biasing circuits and small signal AC models. Design and analysis of operational amplifier circuits, and their use in simple active filters is studied.

Website:

CULearn Elec2507 account will be periodically updated for information regarding the course

Lecture Schedule:

	Lecture: Section A	Lecture: Section B
Day & Time	Tue, Thu: 11:35am – 12:55pm	Wed, Fri: 1:05pm-2:25pm
Room(s)	AT-302	CO-372

Course Organization:

The course consists of lectures, laboratory exercises and problem analyses (PA) sessions.

Prerequisites:

Pre-requisite for the course are listed in the undergraduate calendar and is ELEC2501. Students without the prerequisite will be de-registered. Students with special requests may contact the instructor; however, it is highly unlikely such requests will be entertained.

Marks:

Labs (5)	25%
PA Tests, Quizzes	25%
Final Exam	50%

Note: To pass the course, all the following three conditions must be satisfied.

1) At least 4 of the 5 labs must be completed with final average lab marks of 50% or better to pass the course (all 5 labs will be counted while computing the lab-total).
2) At least 4 of the 5 Tests must be completed with final average PA marks of 50% or better to pass the course (all 5 Tests will be counted while computing the PA-total).
3) Final exam may differ from PAs in terms of complexity of questions and presentation of answers. At least 45% on the final exam is required to pass the course (final examination is for evaluation purposes only and the paper will not be returned or shown to the student).

Learning outcomes:

By the end of this course, students will be able to:

- Understand the semiconductor physics, difference between p and n type materials, p-n junction and its biasing and be fluent with the related modeling
- Understand the functioning of fundamental electronic devices, namely diodes, Bipolar Junction Transistors (BJTs), Metal Oxide Semiconductor Transistors (MOSFETs) and Operation Amplifiers (Op-Amps)
- Understand the functioning of fundamental electronic design modules, namely, Rectifier Circuits, Op-amp based filter circuits and Amplifier Circuits
- Model the behaviour of fundamental electronic devices, namely diodes, BJT and MOSFETs in the presence of both the DC and AC signals
- Analyze the circuits with diodes, BJTs and MOSFETs in the presence of both DC and AC signals
- Design Rectifier Circuits, Op-amp based filter circuits and BJT/MOSFET based Amplifier Circuits
- Differentiate and select between various amplifier configurations (CE/CC/CB, CS/CD/CG)
- Differentiate and select between various amplifier configurations between various filter configurations (Low-pass, High-pass, Band-pass, Band-Stop)
- Construct, experimentally measure and verify the characteristics of the Diodes, BJTs and MOSFETs and figure-of-merits of Rectifier Circuits, filter circuits and Amplifier Circuits and to prepare detailed lab reports on the related experiments

LAB: Students will work individually in the lab to perform the experiments and submit a report with necessary theory, data, calculations, graph as well as conclusions and discussions, at the end of the lab. The reports will be marked, and returned to you during your next-lab-turn (after two weeks). Lab report can be maintained as a collection of booklets for each lab (no need to maintain one report-book for the whole course).

LAB Exemptions: No Laboratory exemptions will be provided.

PA: Problems for each week's PA sessions will be assigned and posted in advance on the ELEC 2507 course website. You are expected to work out these problems and self-evaluate yourself before coming to the PA. The PA sessions are to help with problem clarification, and to answer conceptual questions. Should you attempt all the assigned questions, the likelihood

you would pass the quiz is higher. The last 45 minutes of the PA session are used to conduct a Test. The tests will be marked and returned during the next PA turn (after two weeks). Attendance will be taken at the beginning of the PA session and also a sign-up sheet will be passed to record the presence in the quiz.

Re-check: Requests for LAB report and PA quiz re-checks must be made to your respective TAs as soon as you receive them. Once you leave the LAB/PA room, you forfeit your right to ask for a re-check.

Missed Labs/PA/Quizzes: In such a case (for medical emergency only) please contact the TA/PA, with-in 24 hours of the missed session, along with the medical certificate for making possible alternative arrangements. In case you were permitted to do your lab/PA in any alternative session, make sure to keep a note of which session you did, who were your TAs, in case your marks were not updated promptly.

Record Keeping: Your TA will update the marks on CULearn regularly. Make sure that they are the correct marks; if not alert your respective TAs immediately. Keep all your PA/lab/prelab reports safely until your final grades are submitted; you may be asked to produce them in case of discrepancy in reported marks.

Important note regarding the queries/communications:

It is important to note that this is a large course with over 300 students registered. To run the course smoothly, there are 6 lab sections (each with Odd/Even groups) and 10 TAs to assist you with labs, PAs and marks keeping. Please adhere to the following guidelines such that any queries you may have are promptly/timely answered:

a) For All your communication to the professor or TAs, **in the subject line**, please start as
   - **ELEC2507 – SN# - any particular message** (this will help us to ensure that your email will come to the course folder in our emails).
   - **Always end the message with your full name** (as registered), **student number as well as your regular lab-section/lab-date** (ex: L1-ODD-Friday), so that we can correctly identify the student in our lists.

b) Any question with respect to your lab/PAs, marks, medical emergencies, first consult your assigned TA, if not resolved, contact your Head TA. Most likely your query is resolved by this stage. **If your query still not resolved, then only contact the professor**.

c) **You are strongly encouraged to make use of the posted office hours of the professor and the TAs**. For general questions regarding lab/PA, you are not restricted to just your TA, **feel free to contact any of the Lab TAs or PA TAs, depending on if it is lab question or a PA question**.

Lecture Outline and Schedule: Following is the broad outline for the course and intended schedule for this term. Minor variations in it may be made by the instructor at the time of teaching and also depending on the circumstances and class schedules.

Lecture Outline (7th edition)

Lecture (week-wise)	Sections in Textbook (7th ed)	Content	Sections in (6th ed)
Weeks – 1& 2	**1.3** **2.1**	Introduction to Analog Electronics: Devices, Circuits, Applications, Digital v/s Analog. Op-Amp Basics	1.3 (summary) 2.1
	2.1, 2.2, 2.3	Op-Amps: Basics, Inverting, Non-inverting Configurations, Buffer Circuits, Summing Circuits Amplifier Basics, Gain, Input, Output Impedances, buffer circuits	2.1, 2.2, 2.3
	2.4	Difference Amplifier, Op-Amp Examples	2.4
	2.5	Integrator and Differentiator Circuits, Frequency Responses	2.5
Weeks– 3 & 4 (Lab1 – Basic circuit theorems starts, PA 1)	**3.1** **3.2, 3.3** **3.4**	Semiconductors - Intrinsic/extrinsic Silicon, Doping – p, n, Diffusion/Drift Currents, Diodes – Concepts of Physical operation: p-n junction formation,	3.1 3.2, 3.3
	3.4-3.6	Barrier Potential, Forward Bias, Diode Current Equation, Reverse Bias, Examples	3.4-3.6
	4.1 **4.2**	Ideal diode: application in logic gates, Examples Characteristic curves,	4.1 4.2
	4.3	Modeling: Exponential Model, Graphical Analysis, Concept of Load Line, Diode Simplified Models: Battery + resistance model, constant voltage drop model, Diode Small signal Model, Examples	4.3
Weeks – 5 & 6 (Lab2- Op-Amps	**4.4**	Breakdown Characteristics – Zener Diode, Voltage regulators	4.4

PA 2)	**4.5** **4.6**	Rectifier Circuits – HWR, FWR Analysis Reading Assignment - Bridge Rectifier Signal Processing Applications: Filter Circuits, Clippers, Clampers *Reading Assignment –-Special Types of diodes: Varactor, LEDs.*	4.5 4.6
	6.1-6.2	Bipolar Junction Transistors – Basics, symbols and conventions, Modes of operation, NPN - Active Mode, Current Relations, Examples, BJT Characteristics, Early Effect, *Reading Assignment – PNP transistor*	6.1-6.2
		D. C. Circuit Analysis, Fixed Bias, Voltage Divider Bias, Collector Feed Back Bias, Examples	6.3
Break Week (neglected in the count of weeks)			
Weeks – 7 & 8 (Lab3- Diodes PA 3)	**7.1**	BJT as an amplifier, Graphical analysis, Transistor as an Amplifier, Examples *Reading Assignment – BJT as a switch*	6.4
	7.2	BJT Small Signal Models, Examples	6.5
	7.3	Single Stage BJT Amplifiers, Common Emitter Amplifier, Examples, BJT – CB, CC Amplifier Analysis	6.6
	5.1	FET - Basics, Comparison: BJT v/s FET, types, n/p channel, construction [*Reading Assignment – p-MOS, CMOS]*	5.1
Weeks – 9 & 10 (Lab4- BJTs PA 4)	**5.2**	n-channel MOSFET – operation as V_{DS} increased, characteristics, MOSFET Regions of operation, Current-voltage relationships, Early effect,	5.2
	5.3	FET: D. C. Analysis; Examples,	5.3
	7.1	MOSFET as an Amplifier, Transfer Characteristics, Examples *Reading Assignment – MOSFET as a switch*	5.4
	7.2-7.3	FET: Small Signal Operation, MOSFET Amplifier Configurations: CS, CG, CD	5.5, 5.6
Weeks – 11, 12, 13 (Lab5 – MOSFETs PA 5)	**7.4**	FET – Current Source Biasing	5.7
	7.5	FET – CS Amplifier Analysis	5.8
	5.4	FET – Body Effect, CG, CD Amplifier Analysis	5.8, 5.9
	Review	Op-amps, Diodes, BJT, MOSFET	Review

Graduate Attributes Assessed:

1. **A knowledge base for engineering:** Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.
2. **Problem analysis:** An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.
3. **Investigation:** An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.
4. **Design:** An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.

This course (ELEC2507) will score graduate attributes 1-4. They are scored through the responses provided in assignments, quizzes, pre-lab and lab reports, presentations, final exams. The graduate attribute scores may in some cases be derived from graded material, however, the graduate attribute scores are not used in determination of the final grade for the course.