Carleton University

Faculty of Engineering, Department of Electronics

ELEC 2507 A/B - Electronic - I

Winter Term 2023

Instructor:

Name	Sections	Office	Email
Prof. Ram Achar	A&B	Online	achar@doe.carleton.ca

Lecture Schedule:

	Lecture: Section A	Lecture: Section B
Day & Time	Tue, Thu: 11:35am – 12:55pm	Wed, Fri: 11:35am – 12:55pm
Room(s)	LA C264	TB360

Office Hours:

	In person	Online
Day & Time	Thu: 1:30pm – 2:30pm	Fri: 1:30pm – 2:30pm
Room(s)	MC 3036	A link will be provided

Course Material, Text Book:

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

Laboratory Manual: *Electronics – I: Laboratory Manual* and *Lab-Tutorial* (both of these will be posted on Brightspace Elec2507A/B cross-list portal)

Course Summary:

This is a first-level Analog Electronics course which introduces the theory of semiconductor physics and p-n junctions. Fundamental electronic devices, namely, Diodes, Bipolar Junction Transistors (BJTs) and Metal-Oxide-Semiconductor Field Effect Transistors (MOSFETs) are introduced, detailing their construction, operation and terminal current-voltage relations. DC as well as Small Signal Analysis, and design of circuits containing these devices are covered. Important design applications for these devices are introduced, including diode-based rectifiers, BJT based CE, CB and CC Amplifiers and MOSFET based CS, CG and CD amplifiers. Design and analysis of operational amplifier circuits, and their use in simple active filters are studied.

Website:

Brighspace-Carleton Elec2507 A&B cross-list portal – website will be regularly updated for information/material regarding the course.

Course Organization:

The course consists of lectures (12 weeks, 1.5 hours of two sessions per week), lab sessions (5 labs of 3 hours each + preparatory session) and problem analyses (PA) sessions (5 sessions of 3 hours each + preparatory session). Students attend Lab and PA sessions in alternate weeks.

Prerequisites:

Mandatory pre-requisite for the course is listed in the undergraduate calendar and is **ELEC2501**. **Students without the prerequisite will be de-registered.**

Marks:

Labs (5)	20%	
PA Session and Quizzes (5)	5%	
Homework Problem Sets (HWPs) (5 each)	15%	(Online)
In class quizzes	5%	(Online)
Midterm Test	15%	(Online)
[**Midterm Exam Date**: *Saturday, Mar 11, 2022; 3pm to 4:30pm*		
Final Exam	40%	

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

1) At least **4 of the 5 labs** must be completed with final average of lab marks of 50% or better to pass the course.
2) At least **4 of the 5 PA sessions** must be completed with final average of PA marks of 50% or better to pass the course.
3) At least **4 of the 5 Homework Problem Sets** must be completed with final average of HWP marks of 50% or better to pass the course. **In-person attendance to PA session of the corresponding cycle is mandatory, else the corresponding HWP will be marked zero while aggregating the course total**.
4) At least 45% on the final exam is required to pass the course. Final exam may differ from HWPs, PAs and Midterm in terms of complexity of questions and presentation of answers.

Midterm Exam is Optional. In case of missed Midterm Test **for any reasons**, weightage of the Mid-term test will be transferred to the final Exam.

Due to the large enrolment nature of the course, no time extensions/switching will be given beyond the specified session/execution/submission deadlines for Labs, PAs or HWP problem sets. Instead, as a form of upfront accommodation for handling any unforeseen circumstances you may face, best 4 out of 5 labs, best 4 out of 5 PA quizzes, best 4 out of 5 HWP marks and best of the 80 % of the all in-class conducted quizzes will be counted towards the course total. Hence plan accordingly and any further requests regarding extensions will not be entertained. Students are strongly encouraged to complete all the 5 sets in each of the Lab, HWP, PA and all in-class-quiz categories.

- **Completion of the pre-lab tasks/questions is mandatory for admission to the lab. Doing Pre-lab tasks during the lab session is not permitted.**

- **Late arrival beyond the scheduled time to the lab/PA sessions is not permitted (admittance will be denied).**
- **Attendance to the Lab and PA sessions are mandatory for marking of the corresponding Lab Reports and PA quizzes.**

LAB: Students will perform the experiments in the lab and submit a report with necessary theory, data, calculations, graph as well as conclusions and discussions, at the end of the lab. **It is expected that the students come to the lab with the completed pre-lab tasks and a draft report for the lab that is to be filled with the actual measurements during the lab and the conclusion.** The reports will be marked and returned to you during your next-lab-turn (after two weeks). Pre-labs reports should be attached to the lab-report before handing in to the TAs.

LAB Exemptions: No Laboratory exemptions will be provided.

HWPs and PA: Homework Problems based on the lectures or pre-requisite materials will be posted every two weeks which also form the basis of the questions for the PA sessions and PA quizzes ELEC 2507 Brightspace portal. **You are expected to work out these problems and self-evaluate before coming to the PA session. The PA sessions are to help with problem/solution clarification and to answer conceptual questions that students may have.**

Re-check: Requests for LAB report and tests must be made to your respective TAs as soon as you receive them, before the end of the session.

Record Keeping: Your TA will update the marks on Brightspace regularly. Make sure that they are the correct marks; if not alert your respective TAs immediately. It is strongly recommended that students keep with them safely, their lab-reports/quizzes/mid-terms tests at least until the final grades are published.

Learning outcomes:

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

1. Explain, Analyze and Design different types of amplifier and filter circuits using operational amplifiers.
2. Explain the theory of semiconductor physics, construction and operation of Diodes, Bi-Polar Junction Transistors (BJTS) and MOSFETS. Also Model the current-voltage relationship of these devices.
3. Perform DC as well as Small Signal Analysis of circuits containing Diodes, BJTs and MOSFETs.
4. Analyze and Design basic electronic building blocks: Diode based Rectifier Circuits, CE/CB/CC BJT Amplifiers and CS/CG/CD MOSFET Amplifiers

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.

Important note regarding the queries/communications:

It is important to note that this is a large course with nearly 300 students registered. To run the course smoothly, there are 6 lab sections (each with Odd/Even groups) and 12 TAs to assist you with labs, PAs, HWPs and marks keeping. Please adhere to the following guidelines such that any queries you may have are promptly/timely answered:

a) **All communications must be made via your official Carleton email id, if not they will not be answered**. 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	**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	**4.4**	Breakdown Characteristics – Zener Diode, Voltage regulators	4.4
	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	**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	**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	**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