UBC Department of Electrical and Computer Engineering

Course Syllabus

ELEC 201 Circuit Analysis I (September 2024)

- The fundamentals of analysis of lumped linear time-invariant circuits; network theorems; operational amplifiers; first order circuits; DC analysis of diodes, BJT, and MOSFET circuits.

- This course is an introduction to circuit analysis, and to basic discrete electronics. This is not a course on physics but on a mathematical abstraction (a model) used to represent a variety of engineering problems (one of which, of course, is the solution of physical electric and electronic circuits). This course assumes that the student has a working knowledge of ordinary linear differential equations, basic integral-differential calculus, and the physics background that describes the basic electromagnetic entities and relationships.

- Pre-requisites: MATH 101 and one of PHYS 102, PHYS 153, PHYS 158.

- Co-requisites: One of MATH 255, MATH 256, MATH 265.

Contact Information

- Instructor: Dr. L. R. Linares P. Eng., CIV
- Please contact the instructors via the Piazza page for the course.
- Teaching Assistants (contact via Piazza or Canvas):
    - 1. Mouad Boudina
    - 2. Hassan Talaeian
    - 3. Pegah Tekieh
    - 4. Zahra Kavian
    - 5. Althaaf Nuhaad
    - 6. Alexander Dudar
    - 7. Madison Duong

Course Structure

- Lectures: Tuesdays and Thursdays 10 am to 12 pm in IRC 6.
- Lab section A: Tuesdays 1 to 3 pm in MCLD 2038.
- Lab section B: Wednesdays 1 to 3 pm in MCLD 2038.
- Lab section C: Thursdays 1 to 3 pm in MCLD 2038.
- Lab section C: Fridays 1 to 3 pm in MCLD 2038.
- Tutorials: Fridays 4 to 6 pm in CISR 1250. This time is exclusively used for midterms. It cannot be skipped.

Course Content

- Basic circuit variables: current, voltage, and power. [L01. L01b, L02, L03, T01a]
- Basic circuit parameters: resistance, inductance, capacitance. Ohm's Law. Passive elements. [L04]
- Ideal sources: independent and dependent. Voltage and current sources. Active elements. [L04]
- Using MultiSim to simulate lab situations with resistors, independent and dependent sources. [T05a, T05b]
- Measuring amps and volts in the laboratory and in MultiSim, the Multimeter. [LAB01b]
- Resistors color code. The breadboard in the laboratory. Measuring amps and volts in a breadboard. [LAB01c, LAB01b]
- Real source models (Thevenin/Helmholtz's and Norton/Helmholtz's). The laboratory power supply settings to emulate an I source and a V source. [2 lectures]
- Basic topology of circuits: node, binary node, branch, loop, window pane loop (WPL). Parallel connection vs. Series connection. [L05]
- Kirchhoff's Laws: Voltage Law (KVL) and Current Law (KCL). [L06]
- Series, parallel, and delta-wye conversions and simplifications of element groups. Voltage divider and current divider. [L10a, L10b, L10c, L10d]
- Modified Nodal Analysis. Current equations for: a) R-branch; b) RV-branch; c) V-branch (*); d) I-branch and RI-branch. Simplifying V-branches. [L08, L09]
- Thevenin Equivalent. Norton Equivalent. Maximum power transfer. Linearity. Superposition. [L10e, L10f, L10g, L11, L12]
- Loop Analysis. [L14]
- The 'p' operator. Differential equations written using the p-op notation. [1 lecture]
- Circuit elements represented as Z(p) impedances. Ohm's Law in the p-notation. Series, parallel, and delta-wye conversions. [2 lectures]
- Inductors and Capacitors stubbornness. Inductors and Capacitors in DC steady state. [1 lecture]
- First order circuits: RC series, and RL series. Initial conditions: C's voltages, and L's currents. [4 lectures].
- The 'p' operator. Differential equations written using the p-op notation. [1 lecture]
- Circuit elements represented as Z(p) impedances. Ohm's Law in the p-notation. Series, parallel, and delta-wye conversions. [2 lectures]
- Introduction to operational amplifiers including modeling, circuit analysis, and basic circuit configurations: non-inverting amplifier, inverting amplifier, current to voltage converter, difference amplifier, etc.
- Introduction to diodes. Modeling of diodes for circuit analysis: ideal diode model, constant voltage drop model, incremental model, and equation model.
- Solution of non-linear circuits using Gauss-Seidel and Newton-Raphson methods.
- Rectifiers and linear power supplies.
- Modeling of Zener diodes for circuit analysis: constant voltage drop and incremental model. The shunt regulator using a Zener diode.
- Limiting circuits using diodes.

- Introduction to Bipolar Junction Transistors (BJTs). The constant voltage drop model and the forward bias equation model. Introduction to the Ebers-Moll model. Regions of operation of BJTs (active, cutoff, and saturation).
- Solution of BJT DC circuits using PNP and NPN transistors. The voltage regulator using a BJT and Zener diode. Current sources using BJTs.
- BJT amplifiers: Common emitter, common base, and common collector amplifiers.
- Introduction to Metal Oxide Field Effect Transistors (MOSFETs): the non-linear quadratic equation of MOSFETs. DC circuits with N-MOSFET and P-MOSFET. Enhancement and depletion MOSFETs. Regions of operations of MOSFETs (saturation, cutoff, and triode).
- Current sources using MOSFETs: the current mirror.

Course Learning Outcomes

- By the end of the course, the student is expected to have gained the insight into the process of modeling that electrical engineers apply to devices and systems.
- The student shall learn to analyze the electric circuit models confidently, correctly and accurately.
- The student has realized that the electric properties of matter, resistance, inductance and capacitance, are both challenges and opportunities to the engineer and their quest for solutions to a better technological society.
- The student should be capable to solve both linear and non-linear circuit containing both dependent and independent voltage and current sources, resistors, diodes, BJTs, MOSFETs, using Modified Nodal Analysis.
- The student should be capable of "linearize" a non-linear circuit containing diodes and transistors in order to obtain a reasonable approximation to the solution of such circuit.
- The student shall come out with the skills necessary to translate diagrams and schematics into bread boarded circuits and utilize laboratory equipment (power supplies, multi-meters, oscilloscopes, and function generators) to implement and test such circuits.

Course Activities and Assessment

- Attendance is monitored in this course, using Top Hat from Monocle. Attendance has two components: (1) Punctuality, taken at 10 am for a minute, (2) Commitment, taken at 11:20 am.
- In every class, there is a participation activity that is deployed using Top Hat from Monocle in which questions associated with the topic of the lecture are open for the class to discuss among themselves and to respond within a given time limit. This participation carries a 10% of the course grade. This participation is a condition to the reward BRP.
- Approximately every week, there is a personalized assignment deployed through the UBC WebWorK server. The assignment does include, more often than not, watching custom made videos on the topics being discussed during the week. Assignments are worth 10% of the course total grade. These grades are a condition to the reward BRP.
- Every other week, during the two-hour session listed as "tutorial", there is a one-hour long midterm that is followed by a team-exam where students, organized in groups/teams of two to six members, discuss the exam that they just took and submitted.

- The actual tutorials have been uploaded to the Internet for students to watch, freeze, rewind and process at their own pace and in their own time.
- Every other week, there is a two hour laboratory session.
- Assessment:
    - Midterms: 5 midterms (every other week at the tutorial time). 7% each for a total of 35%.
    - Final Exam: 40%. This exam is comprehensive. You must pass this exam in order to pass the course.
    - In Class Participation: 10%. Via top-hat. You must be present in the classroom.
    - Laboratories: 5%. (A small percentage, but must pass to take the final exam)
    - Homework: 10% (via Webwork/UBC every one or two weeks).

Required Materials

- ELEC201 lab kit. This lab kit is the same used in ELEC211/ELEC291/ELEC292/ELEC391/Capstone. You only need to buy one kit. Availability and cost will be provided in class. The approximate cost of this kit is CAD $130.
- Scientific Graphic Calculator HP-Prime. This calculator is mandatory in ELEC201, ELEC202, and ELEC342. Approximate cost CAD $200. You may instead use the HP Prime Emulator on your laptop, which is free (even in exams).
- Top-Hat subscription. Attendance and class participation is carried out using top hat. Approximate cost is USD $50 per year. This subscription will be used for ELEC202 as well (no extra payment). Please visit https://tophat.com/ for more information.

Course Policies

- The student must pass the final exam (50%) in order to be eligible to pass the course. The final examination has two parts, the circuits part, and the electronics part. The student must pass both parts; that is, students must get in each part a grade better or equal to 25% of the total exam. If a student fails one of the two parts, that part grade becomes the grade of the final exam. If the student fails the final exam, the course grade becomes the minimum between 45 and the sum of the averages of all the course components for that student.
- The student must pass the laboratories (50%) in order to be eligible to pass the course.
- If the student passes the final examination, to pass the course the aggregate of all the assessments must be greater or equal to 50%.
- Backward Replacement Policy (BRP): If the student has an attendance record better or equal to 90%, an average in assignments no less than 85%, and an in-class participation no less than 65%, then any midterm with a grade below the final's acquires the final exam's grade.

Resources

- Discussion forum in Piazza: Go to Canvas and click on Piazza.
- Class slides will be published on Piazza/Resources as the term progresses.
- Exercises and homework on Piazza/WeBWorK.

- The course has a video counterpart that supplements the live lectures with several hundreds videos uploaded to YouTube, both lectures and tutorials, as well as some prelabs as an example, https://tinyurl.com/elec201-sample1 and this other one https://tinyurl.com/elec201-sample2.

University Policies

UBC provides resources to support student learning and to maintain healthy lifestyles but recognizes that sometimes crises arise and so there are additional resources to access including those for survivors of sexual violence. UBC values respect for the person and ideas of all members of the academic community. Harassment and discrimination are not tolerated nor is suppression of academic freedom. UBC provides appropriate accommodation for students with disabilities and for religious, spiritual and cultural observances. UBC values academic honesty and students ae expected to acknowledge the ideas generated by others and to uphold the highest academic standards in all of their actions. Details of the policies and how to access support are available here.