Fall 2023

CSE250 – Circuits and Electronics

INTRODUCTION TO CSE250

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Course content

- Fundamental electrical concepts and measuring units of electrical charge, voltage, current, resistance, and power; Laws of electricity (Ohm's law, Kirchhoff's Current and Voltage law) and various methods of electrical circuit analysis (Nodal, Mesh); Introduction to basic electrical circuit elements; I-V characteristics; Circuit analysis in Direct current, First-order Transient and Alternating current mode, for various combinations of Resistive, Inductive and Capacitive networks; Phasor representation of sinusoidal quantities; Circuit theorems for linear circuits (Source Transformation, Superposition, Thevenin, Norton and Maximum Power Transfer); Open loop and closed loop configuration of Operational Amplifiers.
- This course includes compulsory 3-hour laboratory work.

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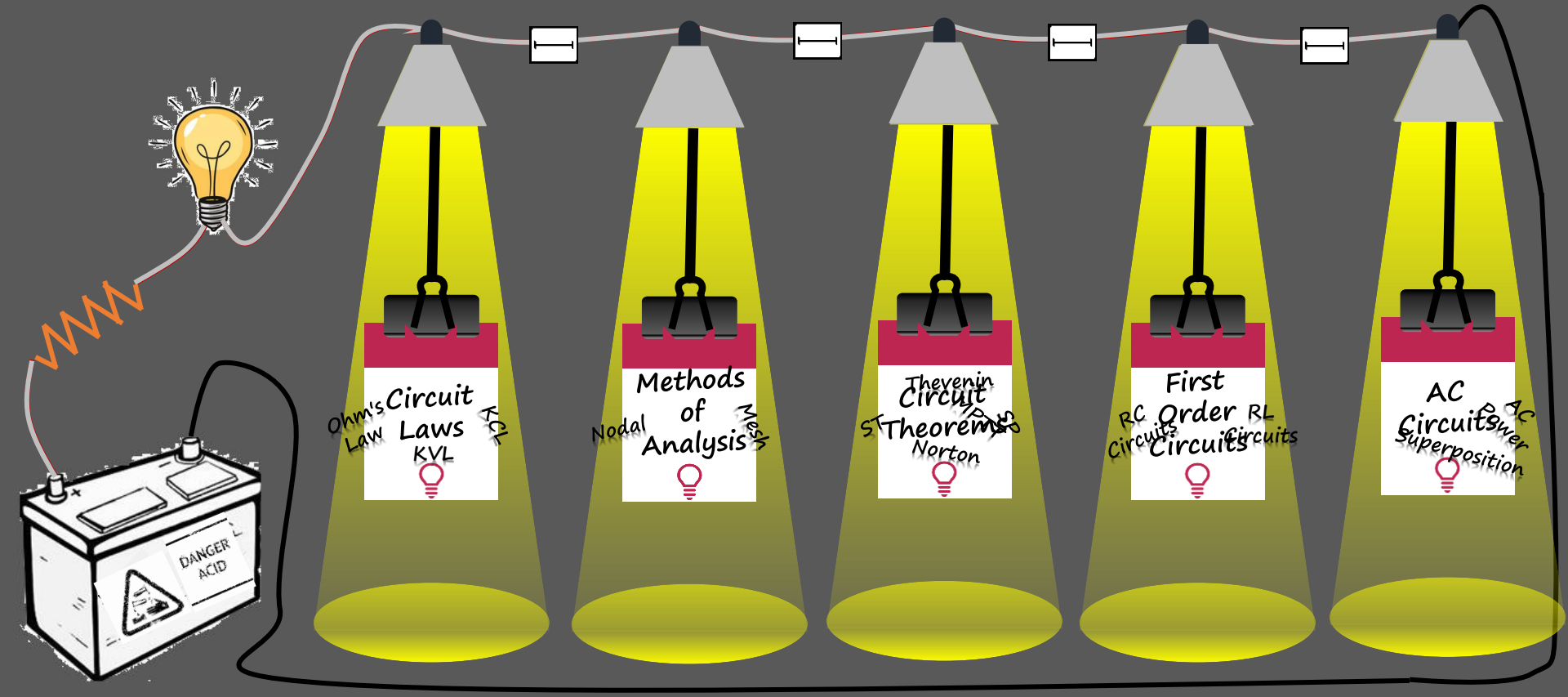
Course Outline: broad themes



Course Objectives

- Introduce students to ideal linear electrical circuit components such as dependent and independent voltage and current sources, resistors, capacitors and inductors and their characteristic equations.
- Illustrate the $I - V$ characteristics of any two-terminal devices and infer circuit equivalence.
- Define physical quantities related to electricity such as voltage, current and power and introduce passive sign convention for computing these quantities.
- Explain fundamental laws like Ohm's law, Kirchhoff's voltage and current law, as well as important linear circuit theorems such as Thevenin's and Norton's theorem, maximum power transfer theorem, superposition principle, and source transformation.
- Familiarize students with several circuit-solving techniques aside from the circuit theorems, such as the voltage/current divider rule, series-parallel circuit equivalence, and nodal and mesh analysis, that take advantage of the fundamental laws and theorems of the linear circuit.
- Analyze first-order transient circuits with resistors, capacitors and inductors in the time domain.
- Introduce operational amplifiers and their use in mathematical computations.
- Introduce phasors and analyze alternating current (AC) circuits constructed from sinusoidal sources, resistors, capacitors and inductors in the phasor domain.

Course Outcomes

Upon successful completion of this course, students will be able to,

Sl.	CO Description	Weightage (%)
CO1	**Understand** and **Describe** the foundational concepts of electricity, including relevant physical quantities and the governing laws that dictate its behavior, such as Kirchhoff's current and voltage law, and Ohm's law, etc.	10
CO2	**Describe** linear circuit theorems, such as superposition principle, source transformation, Thevenin and Norton's theorem, maximum power transfer theorem, and demonstrate the ability to **Apply** them efficiently.	35
CO3	**Analyze** the behavior of analog electrical circuits constructed from networks of diverse linear elements by utilizing various tools, including nodal and mesh analysis, circuit equivalence, voltage and current divider rules, and phasors domain analysis.	35
CO4	**Demonstrate** competence in using laboratory equipment, such as oscilloscopes, function generators, and multimeters, to build, test, and verify analog circuits, and troubleshoot circuit problems.	12
CO5	Collaborate effectively in a group in the laboratory, and **Report** their findings and insights clearly and concisely, using technical language and documentation standards.	3
CO6	**Design**, **Construct** and **Execute** an electrical project that demonstrates the application of electrical and electronic devices and circuits to a real-world problem.	5

Lesson plan

No	Topic	Lecture #
1	Illustrating the motivation behind taking this course. What are the real-life implications of these course materials?	Lecture 1
2	Discuss basic circuit parameters like voltage, current, energy and power definitions and units. Introducing passive sign convention, positive-negative voltage/current/power. Discuss different types of circuit elements (active, passive), and different types of sources (DC/AC, voltage/current, dependent/independent). Introducing circuit symbols.	Lecture 2
3	Introducing basic electrical components: resistors, voltage source, current source. Basic laws of electrical circuits: Ohm's law. I-V characteristics of a resistor. Discuss passive sign convention, finding power of circuit elements by P=VI. Defining nodes, loops and mesh. Discuss various circuit configurations: Series, Parallel and others. How to identify series and parallel connections and calculate equivalent resistance. Open and short circuit.	Lecture 3
4	Defining Node/Supernode. Introducing Current Sign Convention. Basic laws of electrical circuits: Kirchhoff's current law. Statement and application of KCL. Current divider rule in a parallel circuit. Illustrating convention doesn't change the KCL equation. Show usefulness of supernode.	Lecture 4
5	Defining Mesh/Supermesh. Revisiting Passive Sign Convention. Basic laws of electrical circuits: Kirchhoff's voltage law. Statement and application of KVL. Voltage divider rule in a series circuit. Illustrating the assumption of the current direction doesn't change the KVL equation. Show usefulness of supermesh.	Lecture 5
6	I-V characteristics of basic circuit elements: Resistor, Voltage source, Current source, Open circuit, Short circuit, any two-terminal device/circuit, a combination of elements (e.g. voltage/current source in series/parallel with resistor). Idea of circuit equivalence. Series-parallel equivalent circuit for resistance/voltage source/current source combinations. Ideal/ non-Ideal current/voltage source. Simplifying circuits by means of equivalence. Basic circuit theorem: Source Transformation theorem. Failure of applying in Wheatstone bridge circuit.	Lecture 6
	Quiz 1	
7	Explaining Nodal Analysis technique, using it to solve for current, voltage, and power in a given circuit (multiple examples).	Lecture 7
8	Reintroducing dependent sources. Demonstrating Nodal Analysis with dependent sources. Problems with floating voltage sources, using Supernodes to solve such circuits.	Lecture 8
9	Explaining MeshAnalysis technique, using it to solve for current, voltage, and power in a given circuit (multiple examples).	Lecture 9

Lesson plan (contd ...2)

10	Demonstrating Mesh Analysis with dependent sources. Problems with common current sources, using Supermeshes to solve such circuits.	Lecture 10
11	Linear circuit elements. Linearity of voltage, current in circuits, and non-linearity of power. Circuit theorem: Superposition theorem. Using superposition theorem for solving DC circuits. Superposition Theorem for circuits with Dependent Sources.	Lecture 11
	Quiz 2	
	Midterm	
12	Reintroduction to circuit linearity, I-V characteristics of linear circuits. Circuit Theorems: Thevenin's theorem. The motivation behind Thevenin's theorem.	Lecture 12
13	Using test voltage/current sources while deactivating sources to find Thevenin's. Solving resistance matching problems for transferring maximum power. Norton's theorem, the relation between Thevenin's and Norton's theorem.	Lecture 13
14	Using Thevenin's/Norton's theorem for solving circuits. Maximum transferable power and condition for it.	Lecture 14
	Quiz 3	

15	Capacitors and Inductors, their component equations. SI unit for measuring capacitance and inductance. Transient circuits, visualizing and analyzing transient circuits.	Lecture 15
16	Response of transient circuit: first order RC circuit, time constant. Analyzing and plotting first-order transient circuit response. Finding capacitor current from capacitor voltage	Lecture 16
17	Response of transient circuit: first order RL circuit, time constant. Analyzing and plotting first-order transient circuit response. Finding inductor voltage from inductor current.	Lecture 17
18	Complex number review. Alternating current, the importance of AC circuit. Visualizing the dynamics of an AC circuit, Amplitude, RMS voltage/current and finding them from a graph.	Lecture 18
19	Introducing Impedance. Defining impedance for various elements, Phasor analysis of an AC circuit. Instantaneous voltage, current and power. Applying superposition theorem on AC circuits containing sources of different frequencies	Lecture 19
	Quiz 4	
	Final Exam	

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Course materials

- Text and reference books

Sl.	Title	Author(s)	Publication Year	Edition	Publisher	ISBN
1	Fundamentals of Electric Circuits	Charles K. Alexander, Matthew N. O. Sadiku	2019	6th	McGraw Hill Education	978-9353165505
2	Introductory Circuit Analysis	Robert L. Boylestad	2013	12th	Pearson Education India	978-9332518612
3	Electric Circuits	James W. Nilsson Susan A. Riedel	2010	9th	Pearson College Div	978-0136114994

- Other materials
  - Lecture Slides
  - Video Lectures
  - Practice Problems
  - Suggested Problems

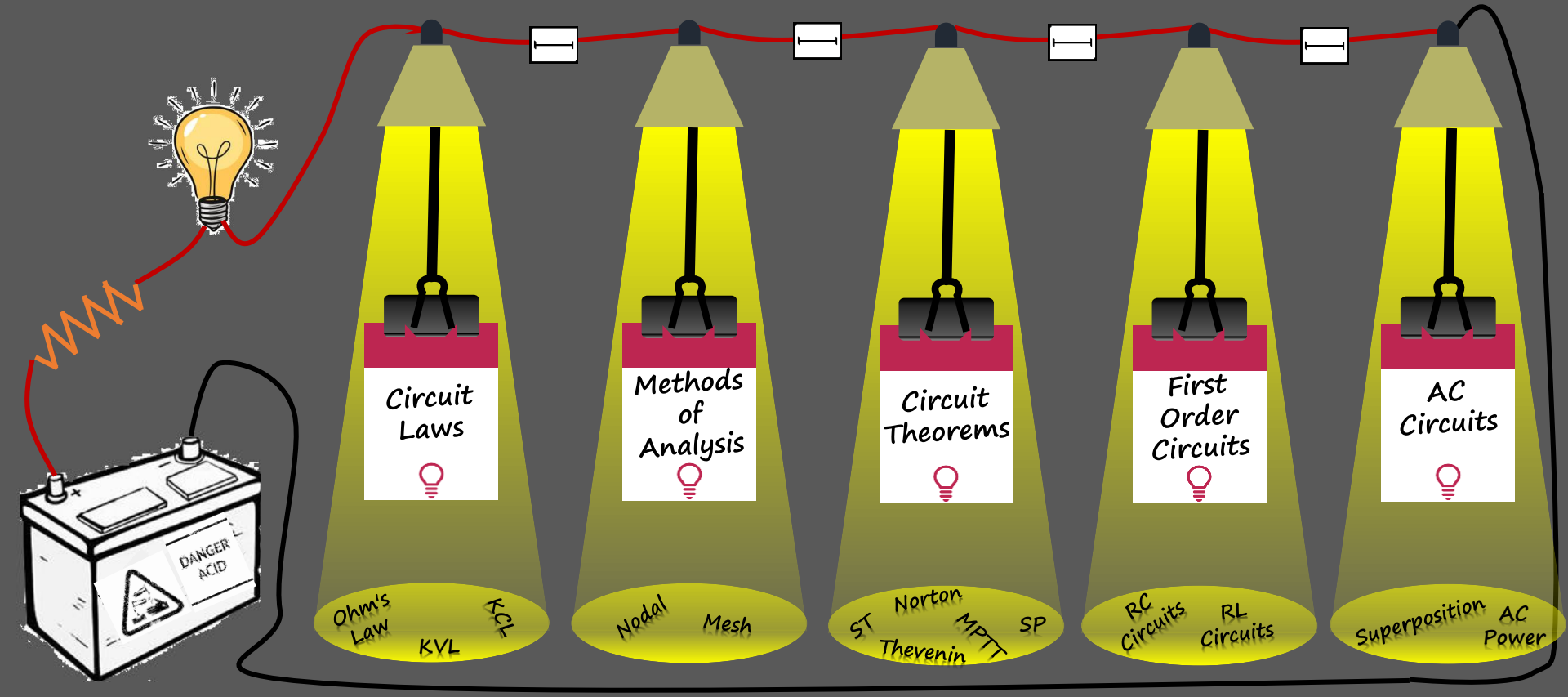
Mark distribution

Assessment	Criteria	Weightage (%)
Attendance		10
Assignment	2 to 4	5
Quiz	Best 3 out of 4	15
Midterm	Central Exam	25
Final	Central Exam	25
Lab	Hardware & Software Experiments	20
Total		100

Presence	Grade (/10)
80% or above	10
75% to below 80%	9
70% to below 75%	8
65% to below 70%	7
60% to below 65%	6
…	…
Below 50%	0

Thank you for your attention

Course Outlines broad themes



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