Course Description and Outcome Form

Department of Computer Science and Engineering

School of Engineering and Computer Science

Brac University

# Course General Information:

| **Course Code:** | CSE250  CSE250L |
| --- | --- |
| **Course Title:** | Circuits and Electronics  Circuits and Electronics Laboratory |
| **Credit Hours** (Theory+Lab): | 3 + 0 |
| **Contact Hours** (Theory+Lab): | 3 + 3 |
| **Category:** | Program Core |
| **Type:** | Required, Engineering, Lecture + Laboratory |
| **Prerequisites:** | None |
| **Co-requisites:** | None |

# Course Catalog Description (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.

# Course Objective:

The objectives of this course are to:

1. 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.
2. Illustrate the I-V characteristics of any two-terminal devices and infer circuit equivalence.
3. Define physical quantities related to electricity such as voltage, current and power and introduce passive sign convention for computing these quantities.
4. 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.
5. 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.
6. Analyze first-order transient circuits with resistors, capacitors and inductors in the time domain.
7. Introduce operational amplifiers and their use in mathematical computations.
8. Introduce phasors and analyze alternating current (AC) circuits constructed from sinusoidal sources, resistors, capacitors and inductors in the phasor domain.

# Course Outcomes (COs):

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, transient analysis, 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 |

# Mapping of CO-PO-Taxonomy Domain & Level- Delivery-Assessment Tool:

| **Sl.** | **CO Description** | **POs** | **Bloom’s taxonomy**  **domain/level** | **Delivery methods**  **and activities** | **Assessment**  **tools** |
| --- | --- | --- | --- | --- | --- |
| **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. | **PO1** | Cognitive /  Understand, Apply | Lectures, Notes/Handouts, Simulation Demo | Quiz, Exam, Assignment |
| **CO2** | **Describe** linear circuit theorems, such as the superposition principle, source transformation, Thevenin and Norton's theorem, maximum power transfer theorem, and demonstrate the ability to **Apply** them efficiently. | **PO1,**  **PO2** | Cognitive /  Understand, Apply, Analyze | Lectures, Notes/Handouts, Simulation Demo | Quiz, Exam, Assignment |
| **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. | **PO2** | Cognitive /  Apply, Analyze | Lectures, Notes/Handouts, Simulation Demo | Quiz, Exam, Assignment |
| **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. | **PO3, PO9** | Cognitive / Apply, Analyze,  Psychomotor / Precision, Manipulation | Lab Class | Lab Work,  Lab Test, Viva |
| **CO5** | Collaborate effectively in a group in the laboratory, and **Report** their findings and insights clearly and concisely, using technical language and documentation standards. | **PO10** | Cognitive /  Apply, Analyze | Lab Class | Lab Report |
| **CO6** | Collaborate effectively in a group to **design**, **construct** and **execute** an electrical project that demonstrates the application of electrical and electronic devices and circuits to a real-world problem. | **PO3, PO9** | Cognitive / Apply, Analyze, Create, Psychomotor / Precision, Manipulation | Lab Class | Lab Project Presentation |

# 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 |
| 3 | Foundations of Analog and Digital Electronic Circuits | Anant Agarwal,  Jeffrey H. Lang | 2005 | 1st | Morgan Kaufmann Publishers | 978-1558607354 |

## Other materials (if any):

1. Lecture Slides
2. Lab handouts
3. Video lectures (Bangla and English)
4. Simulation tools
   1. LTspice
   2. Everycircuit

# **Lesson Plan:**

| No | Topic | Week/Lecture# | Related CO (if any) |
| --- | --- | --- | --- |
| 1 | Illustrating the motivation behind taking this course. What are the real-life implications of these course materials? | Week 1/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. | Week 1/Lecture 2 | CO1 |
| 3 | Introducing basic electrical components: resistors, voltage source, current source. I-V characteristics of a circuit element. Basic laws of electrical circuits: Ohm’s law. Using Ohm’s law to find power. Discuss various circuit configurations: Series, Parallel etc. How to identify them and calculate equivalent resistance. Open and short circuit | Week 2/Lecture 1 | CO1 |
| 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. The usefulness of supernode. | Week 2/Lecture 2 | CO1 |
| 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. The usefulness of supermesh. | Week 3/Lecture 1 | CO1 |
| **Quiz 1 (Lec 1-5)** | | | |
| 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). | Week 4/Lecture 1 | CO1 |
| 7 | Idea of circuit equivalence. Equivalence with inactive current/voltage sources. Series-parallel equivalent circuit for resistance/voltage source/current source. Ideal/ non-Ideal current/voltage source. Calculating equivalent resistance of a series-parallel circuit. Basic circuit theorem: Source Transformation theorem. Failure of applying in Wheatstone bridge circuit. | Week 4/Lecture 2 | CO2 |
| 8 | Explaining Nodal Analysis technique, using it to solve for current, voltage, and power in a given circuit (multiple examples). | Week 5/Lecture 1 | CO3 |
| 9 | Reintroducing dependent sources. Demonstrating Nodal Analysis with dependent sources. Problems with floating voltage sources, using Supernodes to solve such circuits. | Week 5/Lecture 2 | CO3 |
| 10 | Explaining Mesh Analysis technique, using it to solve for current, voltage, and power in a given circuit (multiple examples). | Week 6/Lecture 1 | CO3 |
| 11 | Demonstrating Mesh Analysis with dependent sources. Problems with common current sources, using Supermeshes to solve such circuits. | Week 6/Lecture 2 | CO3 |
| **Quiz 2 (Lec 6-11)** | | | |
| **Midterm (Lec 1-11)** | | | |
| 12 | Linear circuit elements. I-V characteristics of linear circuits. Circuit Theorems: Thevenin’s theorem. The motivation behind Thevenin’s theorem. | Week 7/Lecture 2 | CO2 |
| 13 | Using Thevenin’s theorem for solving circuits. Condition for maximum power transfer. Norton’s theorem, the relation between Thevenin’s and Norton’s theorem. | Week 8/Lecture 1 | CO2 |
| 14 | Using test voltage/current sources while applying Thevenin’s and Norton’s theorem. Solving resistance matching problems for transferring maximum power. | Week 8/Lecture 2 | CO2 |
| 15 | Reintroduction to circuit linearity, linearity of voltage, current in circuits, and non-linearity of power. Circuit theorem: Superposition theorem. Using superposition theorem for solving DC circuits. | Week 9/Lecture 1 | CO2 |
| 16 | Solving circuits using superposition theorem with dependent sources. | Week 9/Lecture 2 | CO2 |
| 17 | Capacitors and Inductors, their component equations. SI unit for measuring capacitance and inductance. Transient circuits, visualizing and analyzing transient circuits. | Week 10/Lecture 1 | CO1 |
| 18 | Response of transient circuit: first order (RC/RL) circuit, time constant. Analyzing and plotting first-order transient circuit response. | Week 10/Lecture 2 | CO3 |
| **Quiz 3 (Lec 12-18)** | | | |
| 19 | Alternative short-hand circuit representation, KCL, KVL, Nodal Analysis. | Week 11/Lecture 2 | CO1 |
| 20 | Op-Amp - introduction, input resistance (i+ = i- = 0), open loop configuration, applications of the op-amp in open loop config (e.g. threshold crossing detection, thermostat control, sinusoidal to square wave generator etc.). | Week 12/Lecture 1 | CO1 |
| 21 | Solving circuits with Op-Amp, examples. | Week 12/Lecture 2 | CO3 |
| 22 | Open feedback (neg, pos), applications: inverting amplifier, non-inverting amplifier, buffer, inverting summer, integrator, differentiator (with problems). | Week 13/Lecture 1 | CO3 |
| 23 | 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. | Week 13/Lecture 2 | CO1 |
| 24 | 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. | Week 14/Lecture 1 | CO3 |
| **Quiz 4 (Lec 19 - 24)** | | | |
| **Final Exam (Lec 1 - 24)** | | | |

# Lab Experiments:

| **No.** | **Experiment Name** | **Type** | **Week/Experiment No.** | **Related CO (if any)** |
| --- | --- | --- | --- | --- |
| 1 | Introduction to Laboratory Instruments (Part 1) | Hardware | Week 2 / Experiment 0 | CO4 |
| 2 | Introduction to Series and Parallel Circuits. | Hardware | Week 2 / Experiment 1 | CO4 |
| 3 | Verification of KVL and KCL. | Hardware | Week 3 / Experiment 1 | CO4 |
| 4 | Verification of Superposition Principle. | Hardware | Week 3 / Experiment 2 | CO4 |
| 5 | Introduction to Laboratory Instruments (Part 2) | Hardware | Week 4 / Experiment 0 | CO4 |
| 6 | I-V Characteristics and Circuit Equivalence. | Hardware | Week 4 / Experiment 1 | CO4 |
| 7 | Introduction to Circuit Simulation using LTspice.  (Dependent sources, I-V characteristics, sweep parameters) | Software | Week 5 / Experiment 1 | CO4 |
| 8 | Verification of Thevenin’s Theorem and Maximum  Power Transfer Theorem. | Hardware | Week 6 / Experiment 1 | CO4 |
| **Midterm** | | | | |
| 9 | Study of Transient Behaviour of RC Circuit. | Hardware | Week 8 / Experiment 1 | CO4 |
| 10 | Applications of Operational Amplifier: Comparator, Inverting Amplifier, Non-inverting Amplifier, Differential Amplifier. | Hardware | Week 8 / Experiment 2 | CO4 |
| 11 | Applications of Operational Amplifier: Inverting Integrator, Inverting Differentiator. (**Hardware)** | Hardware | Week 9 / Experiment 1 | CO4 |
| 12 | Familiarization with the alternating current (AC) waves. | Hardware | Week 10/ Experiment 1 | CO4 |
| 13 | Transient and AC Circuit Simulation using LTspice. | Software | Week 11 / Experiment 1 | CO4 |
| 14 | Open practice for Lab Test | Hardware | Week 12 / Practice | CO4 |
| **Lab Project Submission** | | | | |
| **Lab Test** | | | | |

# Assessment Tools:

## Theory:

| **Assessment Tools** | **Weightage (%)** |
| --- | --- |
| Class Performance and Participation | 10 |
| Quiz | 15 |
| Assignment | 5 |
| Midterm Examination | 25 |
| Final Examination | 25 |
| **Total** | **80%** |

## Lab:

| **Assessment Tools** | **Weightage (%)** |
| --- | --- |
| Lab Attendance and Performance | 5 |
| Lab Report | 3 |
| Lab Test | 7 |
| Lab Project | 5 |
| **Total** | **20%** |

# CO Assessment Plan:

| **Assessment Tools** | **Course Outcomes** | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **CO1** | **CO2** | **CO3** | **CO4** | **CO5** | **CO6** |
| Quiz | ✔ | ✔ | ✔ |  |  |  |
| Assignment | ✔ | ✔ | ✔ |  |  |  |
| Midterm Examination | ✔ | ✔ | ✔ |  |  |  |
| Lab Work |  |  |  | ✔ |  |  |
| Lab Report |  |  |  |  | ✔ |  |
| Lab Project |  |  |  |  |  | ✔ |
| Lab Test |  |  |  | ✔ |  |  |
| Final Examination | ✔ | ✔ | ✔ |  |  |  |

# CO Attainment Policy:

As per the course outcome attainment policy of the Department of Computer Science and Engineering.

# Grading Policy:

As per the grading policy of the Department of Computer Science and Engineering.

# Course Coordinators:

1. Shadman Shahriar (shadman.shahriar@bracu.ac.bd)  
   Lecturer, Department of Computer Science and Engineering, BracU
2. Purbayan Das (purbayan.das@bracu.ac.bd)  
   Lecturer, Department of Computer Science and Engineering, BracU
3. Saiful Bari Iftu (saiful.bari@bracu.ac.bd)  
   Lecturer, Department of Computer Science and Engineering, BracU