CSE251- Handout Fall 2024

A. Course General Information:

Course Code:	CSE251 CSE251L
Course Title:	Electronic Devices and Circuits
Credit Hours (Theory+Lab):	3 + 0
Contact Hours (Theory+Lab):	3 + 3
Category:	Program Core
Type:	Required, Engineering, Lecture + Laboratory
Prerequisites:	CSE250
Co-requisites:	None

B. Course Catalog Description (Content):

Introduction to semiconductors, p-type and n-type semiconductors; I-V characteristics of Non-linear devices; p-n junction diode characteristics; Diode applications: half and full wave rectifiers, regulated power supply using zener diode, diode-logic circuits. Bipolar Junction Transistor (BJT): principle of operation, I-V characteristics; Operational Amplifiers (OPAMP): linear applications of OPAMPs – summer, subtractor, differentiator, integrator; gain, input and output impedances; Application of OPAMPs as comparator; Transistor circuit configurations (CE), BJT biasing, load lines; Switching circuits using BJTs; Small-signal analysis of single-stage amplifiers. Field Effect Transistors (FET): principle of operation of MOSFET; Depletion and enhancement type NMOS and PMOS; biasing of FETs; Switching circuits using FETs; Mathematical analysis of BJT and MOSFET based circuits; The course includes a compulsory 3 hour laboratory work each week.

C. Course Objective:

The objectives of this course are to:

a. Introduce Electronic Devices such as Diodes and Transistors, and, semiconductor physics principles used to make them
b. Introduce the Piece-Wise Linear modeling technique to analyze circuits with non-linear devices
c. Show the application of diodes in constructing various circuits, such as, rectifiers, regulators, etc.

d. Show the application of transistors in building switching circuits and amplifiers with appropriate biasing methods.
e. Introduce students to the Operational Amplifier, it's application as a comparator and also in different circuits to perform analog signal-processing tasks, such as, Summing, Subtracting, Exponentiating, etc.
f. Training students to prototype circuits in hardware and analyzing their behavior
g. Exposing students to Circuit simulation tools to aid them in analyzing circuit behavior before implementing them in real life.

h. Guiding students to complete a project using transistors, Op-Amps to implement their knowledge of Non-linear devices.

D. Course Outcomes (COs):

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

Sl.	CO Description	Weightage (%)
CO1	**Understand** and **compare** the characteristics and operation of electronic devices such as Diode, BJT, MOSFET and Op-Amps.	10%
CO2	**Analyze** the behavior of electronic circuits consisting of different non-linear electronic devices such as Diodes,BJT, MOSFETs using tools such as piece-wise linear modeling and method of assumed states	25%
CO3	**Design** various electronic circuits for power-generation and analog signal-processing applications such as rectifiers, regulators, switching, analog-to-digital and digital-to-analog conversion, amplification, performing arithmetic operations on analog Signals, e.g, summing, subtracting, exponentiation and generating voltage waveforms of different shapes.	35%
CO4	**Demonstrate** competence in using electronic laboratory equipment to build, test, and troubleshoot electronic circuits.	15%
CO5	Collaborate effectively in a group to design, build and **execute** a project that demonstrates the application of electronic devices and circuits to a real-world problem.	10%

E. 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 **compare** the characteristics and operation of electronic devices such as Diode, BJT, MOSFET and Op-Amps	**PO1**	Cognitive/Analyze, Understand	Lectures, Notes/Handouts, Simulation Demo	Quiz, Exam, Assignment
CO2	**Analyze** the behavior of electronic circuits consisting of different non-linear electronic devices i.e. Diodes,BJT, MOSFETs using appropriate models and methods such as piece-wise linear models and Method of assumed states	**PO2**	Cognitive/Analyze, Apply	Lectures, Notes/Handouts, Simulation Demo	Quiz, Exam, Assignment
CO3	**Design** various electronic circuits for power-generation and analog signal-processing applications such as rectifiers, regulators with diodes, switching and amplification using transistors and perform arithmetic operations on Analog Signals, e.g, Summing, Subtracting, Exponentiation using Op-Amps.	**PO3, PO5**	Cognitive/Evaluate, Apply,Analyze	Lectures, Notes/Handouts, Simulation Demo	Quiz, Exam, Assignment
CO4	**Demonstrate** competence in using laboratory equipments to build, test, and troubleshoot electronic circuits	**PO3, PO9**	Cognitive/ Analyze, Apply, Psychomotor/ Precision, Manipulation	Lab Class	Lab Work, Lab Test
CO5	Collaborate effectively in a group to design, build and **execute** an electronic project that demonstrates the application of electronic devices and circuits to a real-world problem.	**PO3, PO9**	Cognitive/Create, Analyze, Apply, Psychomotor/ Precision, Manipulation	Lab Class	Lab Work, Q/A, Presentation

F. **Course Materials:**

i. **Text and Reference Books:**

Sl.	Title	Author(s)	Publication Year	Edition	Publisher	ISBN
1	Foundations of Analog and Digital Electronic Circuits	Anant Agarwal, Jeffrey H. Lang	2005	1st ed.	Morgan Kaufmann Publishers	978–1–55–860735–4
2	Microelectronic Circuits	Adel S. Sedra, Kenneth C. Smith	2015	7th ed.	Oxford University Press	978–0–19–933913–6
3	The Art of Electronics	Paul Horowitz, Winfield Hill	2016	3rd ed.	Cambridge University Press	978–0–521–80926–9
4	Operational Amplifiers and Linear Integrated Circuits	Robert F. Coughlin, Frederick F. Driscoll	2001	6th ed.	Prentice Hall	978–0–130–14991–6

ii. **Other materials**

a. Lecture Notes/Handouts
b. Video Lectures (buX Course – Circuits and Electronics)
c. Lab Sheets

G. Lesson Plan:

Theory

No	Topic	Week/Lecture#	Related CO (if any)
	History and Importance of Electronic Devices – Diodes, Electronic Switches and Amplifiers, Transition from Mechanical Switches to Vacuum Tubes to Solid State Devices, Current State-of-the-Art in Electronics/Semiconductor Technology	Lecture-1	CO1
	Alternative circuit representation; Review of KCL,KVL, Nodal analysis	Lecture-2	CO3
	Introduction to Operational Amplifiers – Differential Amplifiers; Solving Op-Amp based circuits using KCL,KVL and Nodal Analysis; Op-Amp Circuits in Open-Loop Configuration – Square Wave Generator, Characteristics of Infinite Gain.	Lecture-3	CO1, CO2
	Op-Amp Circuits in Closed Loop Configuration - Controlling Gain through Negative Feedback, Virtual Ground Op-Amp Circuits in Closed Loop Configuration – Inverting Amplifier, Non-Inverting Amplifier,	Lecture-4	CO2,CO3
	Op-Amp applications in Follower, Buffer, Inverting Weighted Summer, Weighted Subtractor, Exponential Converter, Logarithmic Converter, Multiplier, Divider, Differentiator, Integrator	Lecture-5	CO2,CO3
	Introduction to I-V Characteristics. I-V Characteristics of: Simple Linear Elements – Resistors, Voltage Source and Current Source; I-V Characteristics of: Degenerate Elements – Open-Circuit and Short-Circuit; Introduction to Diode; Schokley Diode Equation and Diode Logic Gates	Lecture-6	CO2
	Diode Logic Gates Continued; CVD and CVD+r diode models; Solving Diode circuits with Method of Assumed States (M.A.S)	Lecture-7	CO1,CO3
	Real diode equation and Characteristics, PWL Model of Diodes, Solving Diode Circuits	Lecture-8	CO1,CO2
Mid-Term Exam			
	Introduction to Rectifiers, Half-Wave Rectifiers and Transfer Characteristics, Full-Wave Rectifiers and Transfer Characteristics	Lecture-9	CO2,CO3
	Rectifiers Revisited – Average Value of Output, Smoothing Capacitor, Peak-to-Peak Ripple, Ripple Factor	Lecture-10	CO3

	Introduction to Electronic Switches, Basic Inverter, Introduction to Controlled Sources, Introduction to MOSFET, Designing Logic gates with MOSFETs	Lecture-11	CO1,CO3
	Constructing a *real* MOSFET – n/p-channel, enhancement/depletion-type MOSFETs. Operation of an Ideal FET- Cut-Off, Saturation and Triode Mode, Output Characteristics,PWL Model and Non-ideal Analysis, Static Analysis	Lecture-12	CO1
	Solving MOSFET Circuits using Method of Assumed States	Lecture-13	CO2
	Solving MOSFET Circuits using Method of Assumed States,	Lecture-14	CO2
	Introduction to BJT, Voltage-Current Conversion using Resistors, Constructing a *real* BJT – npn and pnp transistors,Ebers-Moll Equation, Current and Voltage controlled logic gates	Lecture-15	CO1
	Operation of an Ideal BJT- Cut-Off, Active and Saturation Mode, Ideal Output Characteristics, PWL Model & Non-ideal Analysis, Solving Transistor Circuits using Method of Assumed States, Problem-Solving	Lecture-16	CO1,CO2
	Solving Transistor Circuits using Method of Assumed States, Problem-Solving;	Lecture-17	CO3
Final Exam			

Important dates

- **October 22nd** (Tuesday) - Classes of Fall 2024 begin
- **Midterm exam -** To Be Announced
- **January 9th** (Thursday) - Last class of Summer 2024
- **Final exam** - To Be Announced

Marks Distribution

Assessment	Percentage	Total number of assessments	Number of assessments to be graded
Attendance	0%	-	-
Assignment	12%	4 to 6	n-1
Quiz	14%	4	Best 3
Midterm	25%	1	1
Final	25%	1	1
Lab	24%	-	-

Exams (subject to change)

Exam	Syllabus
Quiz 1	Lecture 2 - 4
Quiz 2	Lecture 5 - 8
Midterm	**Lecture 1 - 8**
Quiz 3	Lecture 9 - 14
Quiz 4	Lecture 15 - 17
Final	**Lecture 9 - 17**

Course Policy

Attendance:

In a tri-semester system, we get about 20 ~ 22 lectures. According to the guidelines provided by the Registrar Office and the Chairperson of the Department of CSE, the following rules should apply for attendance of these classes:

- Attendance in the classes is **mandatory** for all undergraduate students.
- Attendance will be recorded in a Google sheet

- Students are required to maintain the following threshold attendance to be eligible for –
  - **Midterm Exam: 70% attendance**
  - **Final Exam: 70% attendance**
- Failing to meet the attendance threshold mentioned above will result in the student being denied permission to sit for the Midterm and Final exam.

- Attendance will be counted in the following 4 categories:
  - **Present (P)**
  - **Absent (A)**
  - **Late (L)**
  - **Excused absence (E)**
- **3 Lates = 1 Absent**
- Only a medical emergency will be considered a valid reason for an **Excused absence**.
- **Excused absences** must be backed by relevant documents (e.g. prescriptions, medical reports)

Quizzes, Midterm Exam and Final Exam

- At least 4 quizzes will be taken.
- Marks of best (n-1) quizzes will be considered.
- Quiz questions should help prepare the students for the midterm and final exams.
- Quiz, midterm, and final may contain bonus questions, but that will be at most 10% of the total marks of the assessment.
- Questions for quiz, midterm, and final are often modified versions of assignments

Assignments

The main point of the assignments is for the students to test their understanding and to get some practice materials for midterm and finals. Hence, all assignments should collectively cover the whole syllabus. There will be **at least 4 to 6** assignments spread throughout the semester, and the marks of best **(n-1)** will be considered. We will try to make sure that the assignment submission deadlines do not overlap with quiz/mid/final dates.

Assignment Collaboration policy

- Can discuss the assignment questions in **study groups**
- Have to understand and write solutions independently (no copying)
- **Collaboration ≠ Copying**, **severe penalty for direct plagiarism**

Late Submission Policy for Assignments

- Up to 2 late days per assignment, **submission won't be accepted after it**
- Total 4 "free" late days
- After the exhaustion of free late days, **submission won't be accepted**
- Medical emergencies (with documents) will be considered separately

Example: If the assignment is due on 16th June 5:00 PM, and a student turns in their assignment before 17th June 4:59 PM, it would be considered as one late day. A student can use up to 4 late days throughout the semester without any penalty. However, assignments submitted two days after the deadline will not be accepted even if the student has free late days available.

Communication Platform

All communication will be done via **Discord only**. Email may be used if necessary.

Things *NOT* to Do

- **Any form of plagiarism/ cheating/ copying may result in negative marking/ grade capping/ suspension from BracU.**
- **Any type of bullying/harassment will not be tolerated.**
- **Messaging/mentioning/emailing faculty in Discord outside of office hours (8 AM - 5 PM). Don't expect the Faculty members to reply to your queries after the office hours.**

Bonus Marks Policy:

Each exam may carry some bonus questions for exceptional students. Bonus marks might be offered within each category, but **will be capped to full marks** within that category. Bonus marks **will not exceed 10%** of the total marks of the exam.

Example: If a student get 1.5 bonus marks in a quiz but gets 14 out of 15 marks in Quiz, then s/he will get, MIN(14+1.5, 15)=15

Course Contents

Lecture 1:

- Intro to the course, Why CSE251
- Brief history of electronics

Lecture 2:

- Alternative circuit representation
- Review of CSE250 topics (KCL, KVL, nodal)

Lecture 3:

- Introduction to Operational Amplifiers – Differential Amplifiers
- Solving Op-Amp based circuits using KCL, KVL and Nodal Analysis
- Op-Amp Circuits in Open-Loop Configuration – Square Wave Generator
- Characteristics of Infinite Gain
- Intro to Op-Amp comparator

Lecture 4:

- Op-Amp Circuits in Closed Loop Configuration - Controlling Gain through Negative Feedback, Virtual Ground
- Op-Amp Circuits in Closed Loop Configuration – Inverting Amplifier, Non-Inverting Amplifier,
- Application of Op-Amp as comparator

Lecture 5:

- Mathematical applications: Using Op-Amp in Follower, Buffer, Inverting Weighted Summer, Weighted Subtractor, Differentiator, Integrator
- **[QUIZ 1]**

Lecture 6:

- Introduction to IV characteristics
- I-V Characteristics of simple Linear Elements – Resistors, Voltage Source and Current Source
- I-V Characteristics of Degenerate Elements – Open-Circuit and Short-Circuit
- Introduction to Ideal diodes, Diode IV characteristics, Diode Logic Gates

Lecture 7:

- Shockley Diode Equation; CVD and CVD+r model of Diode
- Piecewise linear approximation. Solving Diode Circuits with Method of Assumed States

Lecture 8:

- Solving Diode Circuits with Method of Assumed States, more examples
- Diode Hybrid Circuits Problem Solving
- **[QUIZ 2]**

Syllabus for the midterm exam ends

Syllabus for the final exam starts

Lecture 9:

- Introduction to Rectifiers
- Halfwave rectifier design and transfer characteristics
- Full-wave rectifier design and transfer characteristics

Lecture 10:

- Half wave & Full-wave rectifier design and transfer characteristics with smoothing capacitor
- Ripple voltage, Average Value of Output, Peak-to-Peak Ripple, Ripple Factor, Input-Output graphs
- Mathematical problems

Lecture 11:

- Introduction to Electronic Switches
- Basic Inverter configuration
- Introduction to Controlled Sources
- Introduction to MOSFETs
- MOSFET as a digital switch (S-Model)
- Designing Logic gates with MOSFETs

Lecture 12:

- Constructing a *real* MOSFET – n/p-channel
- Operation of an Ideal FET- Cut-Off, Saturation and Triode Mode
- Output Characteristics
- PWL Model and Non-ideal Analysis: SR model
- Real MOSFET equations
- Introduction to Static analysis
- **[QUIZ 3]**

Lecture 13:

- VTC of NAND gate and static analysis
- MOSFET in DC
- Introduction to Method of assumed state for MOSFET

Lecture 14:

- Method of assumed state for MOSFET

Lecture 15:

- Introduction to BJT, Constructing a *real* BJT – npn and pnp transistors, Ebers-Moll Equation
- Voltage-Current Conversion using Resistors
- S-model of BJT
- Current & voltage controlled logic gates

Lecture 16:

- Operation of an Ideal BJT: Cut-Off, Active and Saturation Mode
- Ideal Output Characteristics
- PWL Model & Non-ideal Analysis
- Solving Transistor Circuits using Method of Assumed States

Lecture 17:

- Method of assumed state for BJT
- **[QUIZ 4]**