CSE251- Handout Spring 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; Hybrid Linear Elements – Voltage Source in series with Resistor, Current Source in parallel with Resistor; Source-Conversion; I-V Characteristics of: Degenerate Elements – Open-Circuit and Short-Circuit; Finding I-V of Series/Parallel Combination;	Lecture-6	CO2
	I-V Characteristics of Piecewise Linear Elements. Finding Device Parameters from I-V Graphs, Problem-Solving; Introduction to Non-Linear Elements: Ideal Diodes	Lecture-7	CO1,CO2
	Constructing a Real Diode – Introduction to Semiconductors, n-type and p-type doping, P-N junction, Schokley Diode Equation and , Diode Logic Gates.	Lecture-8	CO1,CO3
	Real diode equation and Characteristics, PWL Model of Diodes, Solving Diode Circuits	Lecture-9	CO1,CO2
	Solving Diode Circuits, Introduction to Rectifiers, Half-Wave Rectifiers and Transfer Characteristics, Full-Wave Rectifiers and Transfer Characteristics	Lecture-10	CO2,CO3
	Rectifiers Revisited – Average Value of Output, Smoothing Capacitor, Peak-to-Peak Ripple, Ripple Factor	Lecture-11	CO3
Mid-Term Exam			
	Introduction to Voltage Regulators, Drawbacks of Voltage Regulation using Diodes, Zener Diodes, Breakdown Voltage. Finding V_{in}(min) and I_{out}(max) of an *ideal* Zener Regulator, Regulators Revisited, Line-Regulation, Load Regulation, Knee Current, Problem-Solving	Lecture-12	CO3
	Introduction to Electronic Switches, Basic Inverter, Introduction to Controlled Sources, Introduction to MOSFET, Designing Logic gates with MOSFETs	Lecture-12	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-13	CO1
	Solving MOSFET Circuits using Method of Assumed States	Lecture-14	CO2
	Solving MOSFET Circuits using Method of Assumed States,	Lecture-15	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-16	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-17	CO1,CO2

	Introduction to Amplifiers ,Common Emitter Amplifiers, Small Signal amplifier	Lecture-18	CO3
	Small Signal amplifier Mathematical examples	Lecture-19	CO3
	Introduction to DTL, RTL	Lecture-20	
Final Exam			

Important dates:

- **Jan 20th** (Saturday) Classes of Spring 2024 begin
- **TBA**: Midterm exam (TBA)
- **April 30th** (Tuesday) Last class of Spring 2024
- **TBA:** Final exam (TBA)

Marks Distribution

Assessment	Percentage	Total number of assessments	Number of assessment to be graded
Attendance	8%	-	-
Assignment	12%	6	Best 5
Quiz	15%	4	Best 3
Midterm	20%	1	1
Final	20%	1	1
Lab	25%	-	-

Exams (subject to change)

Exam	Syllabus
Quiz 1	Lecture 1 - 5
Quiz 2	Lecture 7 - 11
Midterm	**Lecture 1 - 10**

Quiz 3	Lecture 13 - 17
Quiz 4	Lecture 16 - 20
Final	**Lecture 11 - 20**

Course Policy

Weekly Classes.

- Theory classes –[USIS Schedule]
- **Attendance policy – Mandatory [at max 3 attendance will be considered]**

Quiz,Midterm and Final

- 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.

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
- Up to 4 “free” late days

- After exhaustion of free late days, per day 25% penalty
- Medical emergencies (with documents) will be considered separately

Example: If the assignment is due on 16th October 5:00 PM, and a student turns in their assignment before 17th October 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**. CSE251 Spring 2024 Discord Server:

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 faculty in Discord outside of office hours (8 AM - 5 PM)

Attendance:

In a tri-semester system, we get about 20 ~ 22 lectures. Following rules should apply for attendance of these classes:

- Attendance will be recorded in a Google sheet and will be shared with the students
- Attendance will be counted in the following 4 categories: **Present (P) / Absent (A) / Late (L) / Excused absence (E) . 3 Lates = 1 Absent = 0.5 marks** penalty of total attendance marks
- **3 absences** should be excused without any penalty
- Excused absences must be backed by relevant documents (e.g. medical reports)
- Class performance marks might be offered based on student's participation, but should not be more than 10% of total attendance marks.
- Students having less than 70% attendance might be reported. In such a case, he/she will be eligible for Midterm and Final exam only if the faculty agrees to it.
- A student with class attendance **below 70%** must consult with the instructor in order to discuss the completion of the course.

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 quiz but gets 14 out of 15 marks in Quiz, then s/he gets MIN(14+1.5, 15)=15

Course Timeline:

BRAC University Year Planner [Mon-Wed]- Spring 2024

Day-Month	January		February		March		April		May	
Fri					1					
Sat					2					
Sun					3					
Mon	1				4	Lecture 11	1	Lecture 19		
Tues	2				5		2			
Wed	3				6	Lecture 12	3	Lecture 20	1	May Day
Thurs	4		1		7		4		2	
Fri	5		2		8		5		3	
Sat	6		3		9		6		4	
Sun	7		4		10		7		5	
Mon	8		5	Lecture 5	11		8		6	
Tues	9		6		12		9		7	
Wed	10		7	Lecture 6	13		10		8	Final Examinations
Thurs	11		8		14		11		9	
Fri	12		9		15	Midterm Examinations	12	Shab-e-Qadr, Eid-ul-Fitr, Naba Barsha	10	
Sat	13		10		16		13		11	
Sun	14		11		17	Birthday of Father	14		12	
Mon	15		12	Lecture 7	18	Lecture 13	15	Lecture 20	13	Last day of Grade
Tues	16		13		19		16		14	
Wed	17		14	Lecture 8	20	Lecture 14	17	Lecture 21	15	
Thurs	18		15		21		18		16	
Fri	19		16		22		19		17	
Sat	20		17		23		20		18	
Sun	21		18		24		21		19	
Mon	22	Lecture 1	19	Lecture 9	25	Lecture 15	22	Lecture 22	20	
Tues	23		20		26	Independence day	23		21	
Wed	24	Lecture 2	21	Int. Mother langug	27	Lecture 16	24	Lecture 23	22	
Thurs	25		22		28		25		23	
Fri	26		23		29		26		24	
Sat	27		24		30		27		25	
Sun	28		25		31		28		26	
Mon	29	Lecture 3	26	Shab-e-Barat		Lecture 17	29	Lecture 24	27	
Tue	30		27				30	Class ends	28	
Wed	31	Lecture 4	28	Lecture 10		Lecture 18			29	
Thu			29						30	
Fri									31	

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

Lecture 6:
- Introduction to IV characteristics
- I-V Characteristics of simple Linear Elements – Resistors, Voltage Source and Current Source & Hybrid Linear Elements – Voltage Source in series with Resistor, Current Source in parallel with Resistor
- Source-Conversion; I-V Characteristics of Degenerate Elements – Open-Circuit and Short-Circuit

Lecture 7:
- Intro to non-linear devices
- IV characteristics of non-linear devices: Introduction to Ideal diodes
- Diode Logic Gates
- Different input voltage analysis
- **[QUIZ 1]**

Lecture 8:
- Introduction to diode [Review]: Constructing a Real Diode – Introduction to Semiconductors, n-type and p-type doping, P-N junction
- Shockley Diode Equation
- Piecewise linear approximation.

Lecture 9:
- Diode non-idealities : Real diode equation and characteristics graphs
- PWL Model of real Diodes : CVD model, CVD+R model

- Introduction to Method of assumed state

Lecture 10:

- Problem solving using Method of assumed states
- Examples
- Introduction to Rectifiers
- Halfwave rectifier design and transfer characteristics
- Full-wave rectifier design and transfer characteristics

Lecture 11:

- 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 12:

- **[QUIZ 2]**

Syllabus before midterm ends

Lecture 13:

- Introduction to Voltage Regulators
- Drawbacks of Voltage Regulation using Diodes
- Zener Diodes : I-V characteristics, breakdown Voltage, voltage regulation using Zener diodes
- Problem-Solving : Conditions of using Zener diode as regulator

Lecture 14:

- 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 15:

- 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

Lecture 16:

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

Lecture 17:

- Method of assumed state for MOSFET

Lecture 18:

- 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 19:

- **[QUIZ 3]**

Lecture 20:

- 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 21:

- Types of amplifiers
- Common-emitter configuration
- Introduction to BJT Small signal amplifier

Lecture 22:

- BJT Small Signal Amplifier Mathematical Examples
- RTL & DTL logic family (brief)

Lecture 23:

- **[QUIZ 4]**