CURRICULUM AND SYLLABUS AFTER BoS

B.TECH. ECE (2021)

KALASALINGAM
ACADEMY OF RESEARCH AND EDUCATION
(DEEMED TO BE UNIVERSITY)
Under sec. 3 of UGC Act 1956.
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BACHELOR OF TECHNOLOGY

ELECTRONICS AND COMMUNICATION ENGINEERING

CURRICULUM AND SYLLABUS

(For the Students Admitted from the Academic Year 2021-22 Onwards)

UNIVERSITY VISION

To be a Centre of Excellence of International Repute in Education and Research

UNIVERSITY MISSION

To Produce Technically Competent, Socially Committed Technocrats and Administrators through Quality Education and Research

DEPARTMENT VISION

To become an internationally leading centre of higher learning and research in the domain of Electronics and Communication Engineering

MISSION

- *To provide quality education in the domain of Electronics and Communication Engineering through periodically updated curriculum, effective teaching learning process, best of breed laboratory facilities and collaborative ventures with the industries*
- *To inculcate innovative skills, research aptitude, teamwork, ethical practices among students so as to meet expectations of the industry as well as society*

B.TECH. E.C.E. PROGRAMME EDUCATIONAL OBJECTIVES

Within a few years of obtaining an undergraduate degree in Electronics and Communication Engineering, the students will be able to:

PEO1: Technical Proficiency:

Succeed in obtaining employment appropriate to their interests, education and will become productive and valued engineers within their companies.

PEO2: Professional Growth:

Continue to develop professionally through life-long learning, higher education, and other creative pursuits in their areas of expertise or interest.

PEO3: Management Skills:

Exercise leadership (management) qualities in a responsive, ethical, and innovative manner

ABET STUDENT OUTCOMES

Graduates of the undergraduate electrical and computer engineering programs will have:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal context.
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyse, and interpret data, and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies

B.TECH. E.C.E. PROGRAMME SPECIFIC OUTCOMES

At the end of the programme, the students will be able to:

PSO1: Apply the basic sciences and engineering knowledge in the design and development of complex systems in the areas related to electronics and communication engineering.

PSO2: Use the cutting-edge hardware and software tools with the obtained technical and managerial skills to design software and systems for applications including signal processing, communication engineering, computer networks, VLSI design and embedded systems.

PSO3: Possess the attitude of continuous learning for producing effective solutions for the applications directly and indirectly related to Electronics and Communication engineering

B.TECH. E.C.E. PROGRAMME OUTCOMES (AS PER NBA)
At the end of the programme, the students will be able to: **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. **Problem analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues, and the consequent responsibilities relevant to the professional engineering practice. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. **Individual and teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. **Life-long learning:** Recognise the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

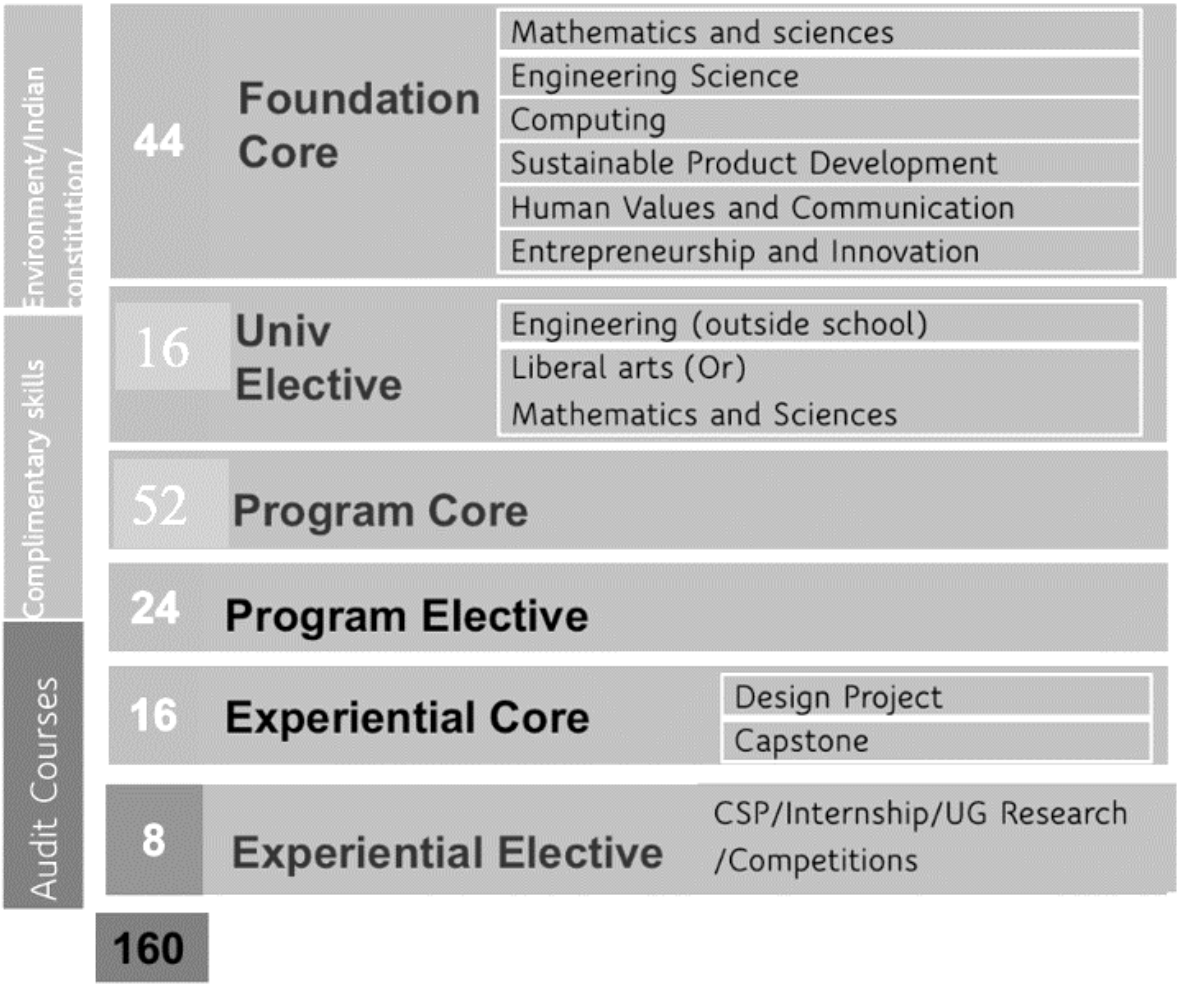
PEOs CONSISTENCY WITH DEPARTMENT MISSION

COMPONENTS FROM DEPARTMENT MISSION	PEO1	PEO2	PEO3
Quality Education	✓	✓	-
Research	✓	✓	-
Teamwork, Ethical Practices	-	-	✓
Innovative Skills	✓	✓	✓
Meet Industrial and Social expectations	✓	✓	✓

POs' CONSISTENCY WITH PEOs'

PEO/ PO, PSO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
PEO1	✓	✓	✓	✓	✓	✓	✓	-	✓	✓	-	✓	✓	✓	✓
PEO2	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	-	✓	✓
PEO3	-	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	-	✓	✓

PROPOSED CURRICULUM STRUCTURE



B.TECH. ELECTRONICS AND COMMUNICATION ENGINEERING – R2021
CURRICULUM

Foundation Core

Sl. No.	Course Code	Course Name	Credits
1	211ECE1100	IoT – Sensors and Devices	2

Program Core

Sl. No.	Course Code	Course Name	Credits
1	212ECE1300	Electronic Devices	4
2	212ECE1301	Digital Circuits and Systems Design	4
3	212ECE1302	Data Communication Networks	4
4	212ECE2303	Electronic Circuit Analysis and Design	4
5	212ECE2104	Signals and Systems	3
6	212ECE2105	Control Systems	3
7	212ECE2306	Analog Integrated Circuits	4
8	212ECE2307	Analog and Digital Communication	4
9	212ECE2308	Microcontrollers and Interfacing Techniques	4
10	212ECE2309	Engineering Electromagnetics	4
11	212ECE2110	Transmission Lines and Waveguides	3
12	212ECE2311	Antennas and Radiation	4
13	212ECE2112	Microwave and Optical Communication	3
14	212ECE2313	Digital Signal and Image Processing	4
		Total Credits	52

Program Electives

VLSI Design and Verification (Nanochip)

Sl. No.	Course Code	Course Name	Credits
1	213ECE2300	IC CAD - Design Automation (Common to VLSI Physical Design)	4
2	213ECE2301	Verilog HDL Programming	4
3	213ECE2302	System Verilog for RTL Verification	4
4	213ECE3303	Advanced SV Constructs and Verification using Python	4
5	213ECE3304	Universal Verification Methodology	4
6	213ECE3305	System Verilog for Verification and Assertion	4

7	213ECE3306	High Level SoC Design Methodologies (Common to VLSI Physical Design)	4

Embedded Systems and IoT (Nanochip)

Sl. No.	Course Code	Course Name	Credits
1	213ECE2307	Object Oriented Programming and Data Structures using Python	4
2	213ECE2308	Embedded Systems for IoT	4
3	213ECE2309	System Design and Applications for IoT	4
4	213ECE3310	IoT Protocols and their Applications	4
5	213ECE3311	IoT Security	4
6	213ECE3312	Smart Textile Technologies	4
7	213ECE3313	Embedded Linux for IoT Systems with Mobile Application Development	4

Artificial Intelligence and Cyber Security (Nanochip)

Sl. No.	Course Code	Course Name	Credits
1	213ECE2314	Cryptography and Network Security	4
2	213ECE2315	Statistical Inference and Machine Learning	4
3	213ECE2316	Deep Learning Implementations in TensorFlow and Keras	4
4	213ECE3317	Applied Data Modelling and Deep Learning for Engineers	4
5	213ECE3318	Cyberspace Operations and Design	4
6	213ECE3319	Applied Cyber Data Analytics	4
7	213ECE3320	Security Data Visualisation	4

Microchip Physical Design (Nanochip)

Sl. No.	Course Code	Course Name	Credits
1	213ECE2300	IC CAD - Design Automation (Common to VLSI Design and Verification)	4
2	213ECE2321	ASIC Design Flow	4
3	213ECE2322	Static Timing Analysis	4
4	213ECE3323	Design For Testability	4
5	213ECE3324	Physical Design and Verification	4
6	213ECE3325	Low Power Logic Synthesis Methodologies	4
7	213ECE3306	High Level SoC Design Methodologies (Common to VLSI Design and Verification)	4

Communication Engineering Stream

Sl. No.	Course Code	Course Name	Credits

1	213ECE3326	Digital Signal Processors and Applications	4
2	213ECE3327	Biomedical Signal Processing	4
3	213ECE2328	Wireless Communications	4
4	213ECE2329	RFID Technologies for IoT	4
5	213ECE3330	Wireless Ad-Hoc and Sensor Networks	4
6	213ECE3331	Optical Networks	4
7	213ECE3332	Natural Language Processing	4

Additional Program Electives for Honours Students

Sl. No.	Course Code	Course Name	Credits
1	213ECE4370	Process and Device Simulation	4
2	213ECE4371	Pattern Recognition and Computer Vision	4
3	213ECE4372	Electronics for Autonomous Navigation Systems	3
4	213ECE4173	Virtual Reality and Augmented Reality	3
5	213ECE4174	Satellite Communication	3
6	213ECE4175	Display Systems	3
7	213ECE4176	Flexible Electronics	3
8	213ECE4377	Wireless MIMO Technology	4
9	213ECE4178	Biochips: Technology and Applications	3
10	213ECE4379	FPGA based System Design	4
11	213ECE4180	Brain Computer Interfacing	3
12	213ECE4381	Embedded Software and Hardware Architecture	4

University Electives by Electronics and Communication Engineering

Sl. No.	Course Code	Course Name	Credits
1	214ECE0100	GPS Fundamentals	3
2	214ECE0101	Electronic Product Design	3
3	214ECE0102	Biosensors and their Applications	3
4	214ECE0103	IoT for Smart Agriculture	3
5	214ECE0104	IoT Network Architecture and Protocols	3
6	214ECE0105	ARM System Architecture	3
7	214ECE0106	Green Electronics Manufacturing	3
8	214ECE0107	Electronics Packaging	3
9	214ECE0108	VLSI Design	3
10	214ECE0109	Fundamentals of Wireless Communications	3

COMMON COURSES (PROPOSED AT UNIVERSITY LEVEL)

S.No	Course Title	L	T	P	X	C	Hrs/Wk
1	English For Engineers	2	0	0	3	**3**	5
2	Introduction to Engineering Visualisation	0	0	2	3	**2**	5
3	Sustainable Product Realisation	1	0	2	3	**3**	6
4	**IoT – Sensors and Devices**	1	0	0	3	**2**	4
5	Problem Solving using Computer Programming	1	0	2	3	**3**	6
6	Python Programming	1	0	2	3	**3**	6
7	Innovation and Entrepreneurship	1	0	0	3	**2**	4
8	Statistics for Engineers	2	0	0	3	**3**	5
9	Calculus and Linear Algebra	3	2	0	0	**4**	5
10	Multiple Integration, Ordinarily Differential Equation and Complex variable	3	0	2	0	**4**	5
11	Physics	3	0	2	0	**4**	5
12	Chemistry	3	0	2	0	**4**	5
13	Basic Electrical and Electronics Engineering	3	0	2	0	**4**	5
14	Biology for Engineers	3	0	0	0	**3**	3

FOUNDATION CORE
(Offered by ECE Department to All B.Tech. Students)

IoT - Sensors and Devices

IoT - Sensors and Devices	L	T	P	X	C
	1	0	0	3	2
Pre-requisite: - **Course Category:** Foundation core (ES) **Course Type:** Theory					

Course Objective:

To expose the students to the fundamental concepts of Microcontrollers and its interfacing, that will help them put a strong foundation for the implementation of Internet of things in real time.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the working of basic electronic components and Sensors.

CO2: Understand the advantages of the different types of Arduino Microcontrollers.

CO3: Apply the knowledge of PWM and Serial communication in different circuits.

CO4: Understand the working of Wi-Fi module and different protocols for communication for usage in IoT.

CO5: Apply the Sensors by building circuits for the given requirements.

CO6: Work effectively in as team and individual in doing the experiments following the safety procedures and ethics and document effectively the experiments carried out in the laboratory.

Mapping of Course Outcome(s):

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	M				L								L		
CO2	L	L			M		L					M	M	M	
CO3	M				L								L		
CO4	M	M	L		M		M					M	M	L	
CO5	L	M	M	L	M	L	M					L	L	M	
CO6								M	M	M					M

Course Topics:

Unit 1: Sensors for IoT

Active and Passive Sensors, Different Types of Sensors such as Capacitive, Resistive, and Surface Acoustic Wave Sensors for Pressure, Humidity, Toxic Gas; Sensors for Water (pH) quality, Accelerometer, Gyroscope, Moisture, Hall effect and Humidity.

Unit 2: Microcontroller

Introduction to microcontrollers and microprocessors, Different microcontrollers, Arduino: Types, UNO Architecture, ADC, DAC, Data acquisition.

Unit 3: Arduino Programming

Digital Pins as Input and Output, Reading Analog Quantities, PWM Pin- Arduino's Serial Port and Serial Communication. Interfacing of DC Motor and Relay

Unit 4: IoT System

Basics of IoT, IoT Levels, Things and Connections, Building Blocks of IoT connectivity (Client-Server, Web Interface, and API: Qualitative Analysis only), Protocols and Communication (Zigbee, Bluetooth, Wi-Fi, MQTT: Qualitative Analysis only), Bluetooth and Wi-Fi Modules for Arduino

Unit 5: IoT Applications

Application of IoT in the industry, buildings, smart city, logistics, environment, health care, agriculture, and lifestyle products.

X-Component Topics:

1. Building basic circuit diagrams using breadboard and Working of a Multimeter.
2. Simple circuit using IC on breadboard.
3. Simple Relay circuit design for ON-OFF condition.
4. Switch on an LED if a button is pressed.
5. Changing brightness of LED using potentiometer.
6. Change the brightness of LED (Fade in/ Fade out) using PWM.
7. DC motor speed control using serial communication.
8. Interfacing Wi-Fi module with Arduino.
9. Sending information about the patient in home to the doctor's PC/mobile.
10. Design a simple circuit to measure the pH value of wastewater.
11. Design a simple circuit to maintain the CO_2 level inside the room.
12. Design a simple circuit to apply Hall effect sensor.

Textbook(s):

1. Peter Dalmaris, "Basic Electronics for Arduino Makers", Packt Publishing, 2017.
2. Tim Pulver, "Hands-On Internet of Things with MQTT: Build Connected IoT Devices with Arduino and MQ Telemetry Transport (MQTT)", Packt Publishing, 2019.
3. Marco Schwartz, "Internet of Things with Arduino Cookbook", Packt Publishing, 2016.

Reference(s):

1. Jody Culkin, Eric Hagan, "Learn Electronics with Arduino: An Illustrated Beginner's Guide to Physical Computing" Make Community, LLC, 2017.
2. Michael Margolis, "Arduino Cookbook" O'Reilly, 2011.
3. Julien Bayle, "C Programming for Arduino", Packt Publishing Ltd., 2013.

PROGRAM CORE

ELECTRONIC DEVICES

ECE21RXXXX	Electronic Devices	L	T	P	X	C
		3	0	2	0	4

Pre-requisite	**:**	Basic Physics at School Level
Course Category	**:**	Programme Core
Course Type	**:**	Integrated Course

Course Description:

This course introduces students to the basic components of electronics: diodes, transistors. The course covers their characteristics and their basic applications.

Course Objective:

To acquaint the students with the construction, theory, and operation of the basic electronic devices such as PN junction diode, Transistors and Opto-electronic devices.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Explain the underlying concepts of Semiconductor Physics.
- **CO2 :** Analyse the working and characterization of PN Junction diodes and its industrial applications.
- **CO3 :** Explain the working of BJTs and special devices and its use in IC design.
- **CO4 :** Comprehend the operation and device characterization of MOS and Nanometre devices and its applicability in IC design.
- **CO5 :** Summarize the concept of IC fabrication and its underlying techniques.
- **CO6 :** Operate electronic equipment and hardware/software tools to analyse the characteristics of electronic devices with an understanding of limitations and impact on environment.
- **CO7 :** Document the technical information related to device analysis efficiently by means of reports.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	H	M										H		
CO2	H	H	L									L	H	M	L
CO3	H	M										H	H	M	M
CO4	H	L	H									M	M		
CO5	H											L	H		L
CO6				M	H	H	H	M						H	L
CO7								L	H	L				H	L

Course Topics:

Unit 1: Semiconductor Physics

Atomic structure, review of quantum mechanics: photoelectric effect, energy band diagrams, Charge carriers – Intrinsic semiconductor, Extrinsic semiconductor, Carrier concentration, Drift, and diffusion – Hall effect, Einstein's relation, Carrier generation and recombination.

Unit 2: PN Junction

Basic PN junction, equilibrium, Forward and reverse bias junction, VI characteristics, Junction breakdown, Junction capacitance – Diodes: Clippers and Clampers, Analysis of diodes circuits, Spice modelling of diodes, small signal model – Metal-semiconductor junction, Zener diode, Interpreting data sheets.

Unit 3: BJT, Special Semiconductor Devices

Introduction to transistors and types of transistors, BJT: Working and I-V characteristics - BJT Configuration types - BJT: Switch, Amplifier (CE) - Non-ideal effects - Equivalent circuits - Eber's-moll - Hybrid-PI model - switching characteristics - Frequency limitations - Application - Spice model and spice code - UJT, LED, Photo diode, Solar cells

Unit 4: MOSFET and Nano-electronic devices

MOS general structure and types of MOS, NMOS working: Vgs/Vds, VI characteristics, MOS capacitor, CV characteristics, PMOS working, VI characteristics, Non ideal effects, Data sheet interpretation, MOS selection, MOS failures, Application examples, Small signal model, MOSFET as switch/pass transistor, transmission gate, CMOS general structure, basic digital gates in CMOS, NMOS current derivation, equating strengths of PMOS and NMOS, unskewed inverter, Skewed inverters, concept of drive strength, Design INV X1, X2, Design NAND X1, NOR X1 (Compare area), MOS switching characteristics, CMOS five regions of operation, Spice models, writing spice code, FinFets and introduction to quantum devices.

Unit 5: Device Technology

IC definition and classification, IC design flow, Layout, DRC rules, Bulk crystal growth, doping techniques, Epitaxial growth, photolithography, double patterning, etching, Monolithic device fabrication, Bonding, and packaging.

Laboratory Experiments:

1 Study of electronic instruments and components
2 Study of function generator, CRO
3 Study of NI ELVIS Kit and measuring real world data.
4 Verify PN-diode working in forward and reverse bias condition and calculate diode forward and reverse bias using NI Elvis kit / Multisim.
5 Verify Zener diode working in forward and reverse bias condition using NI Elvis kit / Multisim.
6 (a) Design and implement voltage limiter circuits for given specification; (b) Design and implement an electronic circuit that changes the DC level of the signal.
7 Plot Input, Output characteristics for BJT in CE mode and Calculate Early voltage
8 Design and implementation of CE amplifier for given specification
9 Determine output, transfer characteristics of Enhancement MOSFET and calculate drain resistance, gm using Multisim.

10 Implement the given digital logic functionality using Pass transistor logic and transmission gates using Multisim

11 Design and implement Unskewed inverter, Hi skewed inverter and low skewed inverter.

12 Calculate cell rise delay, cell fall delay and output transition in CMOS Inverter using Multisim. (Performance Analysis of CMOS Inverter).

Textbooks:

1. Ben G. Streetman and Sanjay Banerjee, "Solid State Electronic Devices", Pearson India, 2016 (Seventh Edition).
2. David Báez-López, and Félix E. Guerrero-Castro, Circuit Analysis with Multisim, Morgan, and Claypool India, 2011.
3. http://nptel.ac.in/courses/122106025/

References:

1. Donald A Neamen and Dhrubes Biswas, "Semiconductor Physics and Devices", McGraw Hill India, 2012 (Fourth Edition).
2. Simon. M. Sze and Kwok K. Ng, "Physics of Semiconductor Devices", Wiley, 2008 (Third Edition).
3. Sima Dimitrijev, "Principles of Semiconductor Devices", Oxford University Press, 2013 (Second Edition).
4. D.K. Bhattacharya and Rajnish Sharma, "Solid State Electronic Devices", Oxford University Press, 2018 (Second Edition).
5. Bart Van Zeghbroeck, Principles of Semiconductor Devices, E-Book, 2011.
6. http://nptel.ac.in/courses/117102061/
7. http://nptel.ac.in/courses/117106091/

DIGITAL CIRCUITS AND SYSTEMS DESIGN

ECE21RXXX	Digital Circuits and Systems Design	L	T	P	X	C
		3	0	2	0	4

Pre-requisite	**:**	Basic Physics at School Level
Course Category	**:**	Programme Core
Course Type	**:**	Integrated Course

Course Description:

Digital circuits are the basic blocks of modern electronic devices like mobile phones, digital cameras, microprocessors, and several other devices. In this course, students will learn the fundamentals of digital circuits and how to engineer the building blocks that go into digital subsystems. Students will learn the basics of combinational as well as sequential logic.

Course Objective:

To introduce the theoretical and aspects of digital electronics, which is the backbone for the basics of the hardware aspect of computers and other modern electronic gadgets

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Explain the basic concepts like Number systems, codes in Digital design
- **CO2 :** Utilise Boolean algebra and its tools in digital design
- **CO3 :** Apply Logic gates and combinational circuits in circuit design as part of their experimentation works with an understanding of their characteristics
- **CO4 :** Apply sequential circuit elements in state machines and digital design as part of their experimentation with an understanding of their characteristics
- **CO5 :** Operate electronic test equipment and hardware/software tools to create, evaluate and troubleshoot digital circuits by applying the knowledge on them with an understanding of their limitations and impact on society, environment
- **CO6 :** Work and communicate as part of a team and as individual effectively in designing digital circuits following the safety procedures and ethics

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H												H		
CO2	H	M	M										H		
CO3	H	M	M									H	H	M	L
CO4	H	M	M									H	H	M	L
CO5	H	M	M	M	H	L	L							H	
CO6								H	H	H	L	L		M	M

Course Topics:

Unit 1: Boolean Algebra

Logic gates, Laws of Boolean algebra, Simplification of Boolean expression using Boolean laws, Minterm, Maxterm, POS, SOP, K-map importance, 3 variable K-map, conversion of POS to SOP and SOP to POS

Unit 2: Analysis and Design of Combinational Logic Circuits – I (Adder, Multiplexer, Encoder)

Analysis and Design of Combinational Logic Circuits – I-Half adder and full adder circuit, Half Subtractor and full subtractor circuit, Design of 4-bit Ripple Adder, Implementation of Carry lookahead adder, Design of 4-bit Parallel Subtractor, 4-bit parallel adder and Subtractor, 2:1, 4:1 and 8:1 multiplexer circuit and its application, 4:2 and 8:3 encoder circuits, Priority encoders and its application, 2:4 decoder and its applications

Unit 3: Analysis and Design of Combinational Logic Circuits – II (Code Converter, Comparator, ALU)

Analysis and Design of Combinational Logic Circuits – II-Code Converter, Binary to Gray code converter and Gray to binary converter, 1-bit and 2-bit comparator circuit, Timing diagram, Propagation delay, Glitches and Hazards, Look Up Tables in FPGA, ALU Design

Unit 4: Analysis and Design of Sequential Logic Circuits – I (Flip – Flops)

Analysis and Design of Sequential Logic Circuits – I-Sequential circuits, Edge triggering, Latch triggering, SR Latch: SR latch implementation with NOR gate and SR latch implementation with NAND gate, Flip-flops: Implementation of JK and T flip flops, Realisation of flip-flops, Characteristic equation, and Excitation table of flip-flops

Unit 5: Analysis and Design of Sequential Logic Circuits – II (Counters, FSM)

Analysis and Design of Sequential Logic Circuits – II-Asynchronous Counters, Ripple counters, draw backs, Synchronous Counters using JK, T flip-flops, Mealy and Moore state machines, Sequence detector design using state machines, FIFO

Laboratory Experiments:

1 Study of NI ELVIS trainer kit

2 For the given specification and requirement, design using NI Elvis kit:
(a) A system to control an automatic sliding door as found in supermarkets
(b) A circuit that monitors chemical level in chemical processing plant
(c) Aircraft functional monitoring system

3 Implement NOT gate, AND gate, OR gate, EXOR gate, and EXNOR gate using ABbar logic

4 Implement Half subtractor and full subtractor using MUX on an NI Elvis kit and verify their functionalities.

5 Shannon's theorem verification – implement the given Boolean function using 4:1 MUX on an NI Elvis kit

6 Implement the given Boolean functionalities with Decoder using NI Elvis kit.

7 Design a 2-bit Magnitude Comparator and check the functionality using NI Elvis kit

8	Design and optimize an ALU for the given functional specification and verify the functionality using NI Elvis kit
9	Design an electronic voting machine with the given specifications and verify its working using NI Elvis kit
10	Design and implementation of 2-bit synchronous up counter and 2-bit synchronous down counter
11	In a micro controller circuit, there are number of sequential circuits operating at different frequencies. Design a digital circuit to convert the clock frequency to required frequencies (Divide by 2 and divide by 4) to be given to respective sequential circuits
12	(a) Design and implement flight attendant call system (b) Design and implement tyre pressure monitoring system for given specification

Textbooks:

1. A. Ananda Kumar, “Fundamentals of Digital Circuits”, Prentice Hall, 2016 (Fourth Edition)
2. G. K. Karate, “Digital Electronics”, Oxford University Press, 2017
3. https://nptel.ac.in/courses/117/106/117106086/

References:

1. John F. Wakerly, “Digital Design: Principles and Practice”, Pearson, 2016 (Fourth Edition)
2. Noel M. Morris, “Digital Electronic Circuits and Systems”, Springer, 2015 (Reprint of 1974 Edition)
3. R. Ananda Natarajan, “Digital Design”, Prentice Hall, 2015 (Second Edition)
4. Alexander Axelevitch, Digital Electronic Circuits, World Scientific Publishing, 2018
5. Roger Tokheim and Patrick Hoppe, “Digital Electronics: Principles and Applications”, McGraw-Hill, 2021
6. https://nptel.ac.in/courses/117/106/117106114/
7. https://nptel.ac.in/courses/117/105/117105080/

DATA COMMUNICATION NETWORKS

ECE21RXXXX	Data Communication Networks	L	T	P	X	C
		3	0	2	0	4

Pre-requisite	**:**	Basic Electronics Engineering course at First Year Level / Equivalent
Course Category	**:**	Program core
Course Type	**:**	Integrated Course

Course Description:

This Course focus on the fundamentals of data communication networks. It familiarizes the students with the basics of data communications, OSI model and techniques, applications, and control of modern data communications networks. Topics included are network models, digital and analog transmission, multiplexing, circuit, and packet switching. This course will mainly focus to develop engineering skills in troubleshooting and designing data networks

Course Objective:

- To give clear idea of signals, transmission media, errors in data communications
- Brief the students regarding protocols and standards.
- To Introduce flow of data, categories of network, different topologies
- To Focus on information sharing and networks. their correction, networks classes and devices.

Course Outcomes:

At the end of the course, the student will be able to:

CO1 : Discuss the concepts of networking and its layers

CO2 : Enumerate the difference between LAN/ MAN /WAN topologies and explain the principles of MAC protocols

CO3 : Review the various routing protocols and able to assign the IP address scheme for a network

CO4 : Describe the services and congestion issues of transport and application layer.

CO5 : Work as a team and individual in laboratory to model and construct network for the given specifications with the knowledge gained on protocols and network layers understanding the limitations and impact.

CO6 : Document effectively the designed network details both in oral and written reports.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	H											H	L	
CO2	H	H					L	L				L	H	M	
CO3	H	H					L					L	H	M	
CO4		H					L					H	H	M	

CO5		L	H	H	H			H	H		L	M	H	M	
CO6								L	L	H				M	L

Course Topics:

Unit 1: Basics of Networks and Link layer

Network Components and Network Topologies (Mesh, Star, Bus, Ring, Hybrid), TCP/IP protocol suit: The Model, Functions of the layers, Error Detection and Correction: Types of Errors, Detection, Parity Check, Cyclic Redundancy Check, Checksum, Error Correction, Link control-layer protocols, PPP, HDLC

Unit 2: Media Access control

IEEE 802 standards–Local Area Networks, Ethernet, Fast Ethernet, Gigabit Ethernet, 10 Gigabit Ethernet, Multiple access control protocols (Categories, Random Access Protocols, ALOHA, CMSA, Controlled Accessed Protocols, Channelisation Methods), Mobile IP, Wireless and Mobility (Bluetooth, Bluetooth Low Energy, Zigbee)

Unit 3: Network layer

Virtual circuit and Data gram networks (Addressing, Phases, Implementation, Delay, Efficiency, Comparison), IPv4, IPv6, ICMP, IGMP, Router and its functions Internet Protocol, Routing algorithms (Classification, Static, Dynamic, Global, Decentralized, Link state routing, Flooding, Distance vector, Dijkstra's Algorithm, k-Shortest Paths Algorithm), Broadcast and Multicast routing algorithms, Unicast routing protocols: Distance Vector Routing Protocol and Link State Routing Protocol, Multicast routing protocols

Unit 4: Transport layer

Transport Layer Protocols and functions: Queuing Disciplines, Reliability, Flow control, Network Socket, Congestion Control, Congestion Avoidance Mechanisms and QoS, Connection-oriented transport, Transmission Control Protocol, User Datagram Protocol, Reliable User Datagram Protocol

Unit 5: Application layer, ATM Network Basics

Principles of network applications, The Web and Hyper Text Transfer Protocol, File transfer, electronic mail, Domain Name System, Secure Shell, TELNET, ATM Networks: Basic Concepts of ATM, Trends in Networking: Sensor networking and Internet of Things introduction

Laboratory Experiments:

1. Study of Network Commands using Command Prompt, configure a network topology using CISCO packet tracer.
2. Perform an initial configuration of a Cisco Catalyst 2960 switch using CISCO Packet Tracer.
3. Configure and troubleshoot a switched network using CISCO Packet Tracer.
4. Connect a switch to the network using CISCO packet tracer and verify the configuration.
5. Study of Bluetooth / Zigbee trainer kit
6. Distinguish the difference between successful and unsuccessful ping attempts; Distinguish the difference between successful and unsuccessful traceroute attempts using CISCO packet tracer.

7 Implement an IP Addressing Scheme using CISCO packet tracer for mobile computing
8 Implement a Modern Static routing and a Modern Dynamic routing using CISCO Packet Tracer.
9 Unicast and Multicast routing protocols for wireless communication / IoT using LAN Trainer Kit / CISCO Packet Tracer
10 Analysis of congestion control techniques in network using LAN Trainer Kit / CISCO Packet Tracer
11 Transport layer Protocols for mobile communication / IoT using CISCO Packet Tracer
12 Configure the customer Cisco 1841 ISR as a DHCP server using CISCO packet tracer.
13 Study of Application Protocols: TELNET, SMTP
14 Socket Programming using Python

Textbooks:

1. Behrouz A. Forouzan, "Data Communications and Networking with TCP/IP Protocol Suite", McGraw Hill, 2021 (Sixth Edition).
2. Jesin A, "Packet Tracer Network Simulator", Packt Publishing, 2014.
3. https://www.coursera.org/specializations/computer-communications

References:

1. Bhushan Trivedi, "Data Communication and Networks", Oxford University Press India, 2016.
2. William Stallings, "Data and Computer Communications", Pearson India, 2018 (Tenth Edition).
3. Oliver C. Ibe, "Fundamentals of Data Communication Networks", Wiley US, 2017.
4. Douglas E. Comer, "Computer Networks and Internet", Pearson India, 2018 (Sixth Edition).
5. Emad Aboelela, Network Simulation Experiments Manual, Elsevier / Morgan Kaufmann, 2012 (Fifth Edition).
6. Larry Peterson Bruce Davie, "Computer Networks: A Systems Approach", Elsevier / Morgan Kaufmann, India, 2011 (Fifth Edition).
7. https://www.edx.org/course/introduction-to-networking
8. https://www.tutorialspoint.com/data_communication_computer_network/index.htm

ELECTRONIC CIRCUIT ANALYSIS AND DESIGN

ECE21RXXXX	Electronic Circuit Analysis and Design	L	T	P	X	C
		3	0	2	0	4
Pre-requisite	**:**	Electronic Devices / equivalent				
Course Category	**:**	Programme Core				
Course Type	**:**	Integrated Course				

Course Description:

The course introduces the analysis and applications of electronic circuits using diodes and transistors. The analysis, selection, biasing, and applications are covered by the course. This course introduces basic signal, spectrum, and amplifier concepts for the analog electronic circuits. Throughout this course, small signal analysis and low frequency operations are mainly considered for the students to have the first interesting impression in this important discipline of the ECE program.

Course Objective:

To make the students capable of analysing any given electrical network.

To gain knowledge about the small signal models of transistor; To acquire an in-depth knowledge of low frequency and high frequency analysis of BJT amplifiers; To design feedback amplifiers, power amplifiers, and oscillators.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Analyse the circuit using Kirchhoff's laws and Network simplification theorems.
- **CO2 :** Apply transform techniques for stead-state and transient analyses.
- **CO3 :** Analyse the common configurations of amplifier models.
- **CO4 :** Design the required power amplifier circuit for the given specifications.
- **CO5 :** Analyse the different RC oscillator circuits to determine the frequency of oscillation.
- **CO6 :** Develop the electronic circuits and interpret the results in laboratory as per the requirements by utilising the tools and equipment effectively, document the results efficiently, as a team/individual work.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M	L									M	H	L	
CO2	H	H	M				M					M		M	M
CO3	H	H	M									M	H		
CO4	H	H	H				M					M	H	M	
CO5	H	H	M					L				M	H	M	

CO6				M	H	H	M	M	H	H	M	M	H	H	M

Course Topics:

Unit 1: Linear and Non-linear Circuit Analysis

Application of nodal and mesh analysis in Circuit Design, Application of Network Theorems (Superposition theorem, Thevenin's theorem, Norton's theorem) in circuit analysis and design; Phasor Circuit Analysis (Sinusoidal steady-state response) of linear electronic circuits; Non-linear elements (Diodes and Transistors), Analysis of Electronic circuits with non-linear elements: Analytical method, Graphical Method (Load line), Piecewise linear analysis, Incremental (Small Signal) analysis

Unit 2: Transient Analysis and Frequency Response of Electronic Circuits

Dynamic circuit analysis (Classical method) of first order and second order R, L, C circuits. Dynamic Circuit analysis in s-domain, Network functions and Sinusoidal response of electronic circuits; Frequency response descriptors, First-Order Low-Pass and High-Pass Responses, Bandpass and Bandstop Responses, Frequency response of RLC circuits.

Unit 3: Transistor (BJT, FET) Amplifier Small Signal Analysis

Dependent sources, Signal amplification (Circuit model of an amplifier, Source and load resistance, Impedance transformation), BJT as 2-port network, Amplifier analysis using h-Parameters; CE amplifier analysis using approximate h-parameter model, small signal analysis of CE and CS amplifier; Distortion in amplifiers, Miller effect, Design of single stage RC coupled BJT amplifier.

Unit 4: Multistage Amplifier, Large Signal Amplifier

Multistage BJT amplifiers (Cascade, Darlington, Cascode) working Case study: Preamplifier for audio; Low Frequency, Mid frequency, and High Frequency response of BJT amplifier, Frequency response of multistage BJT amplifiers; Power amplifiers: Class A, Class B, Class AB, and Class C amplifiers.

Unit 5: BJT Feedback Circuits

Feedback (Positive feedback, Negative feedback), Conditions for Oscillations, RC Phase shift oscillator, and Piezo Quartz Crystal oscillator using BJT, Astable and Monostable multivibrators using BJT; Negative Feedback BJT amplifier (Characteristics, Effect of Negative Feedback on input and output impedances); Types of feedback BJT amplifiers: Voltage series, Current series, Voltage shunt and Current shunt

Laboratory Experiments:

1 Design the values of RB and RC of Fixed bias (DC analysis) using KVL and verify experimentally using breadboard / simulation.

2 Design the values of RB and RC of Fixed bias (DC analysis) using KVL and verify experimentally using breadboard / simulation.

3 Find the Small signal analysis parameters of a LED/Diode using breadboard / simulation.

4 Analyse the transient behaviour of a first-order Op-Amp circuit (with zero input and initial condition) using simulation software (Multisim / equivalent)

5 Find the frequency response of Op-Amp circuit using simulation software (Multisim / equivalent)
6 Find h-parameters of transistor in Common Emitter amplifier Design using breadboard/simulation.
7 Design a Multistage amplifier for preamplification of microphone signal using simulation software.
8 Drive an LED with a Darlington pair as a switch using Breadboard / simulation
9 Find the frequency response of CE amplifier using Breadboard
10 Verify a Power amplifier working based on Class AB complementary output stage and Class A driver stage for Audio applications using simulation software.
11 Design a timer-based LED flasher using multivibrator using breadboard / simulation.
12 Simulate a simple RC phase shift oscillator using BJT

Textbooks:

1. Neamen, Donald A, "Microelectronics: Circuit Analysis and Design", McGraw-Hill, 2010 (4th Edition).
2. Smarajit Ghosh, "Network Theory Analysis and Synthesis", Prentice Hall, 2015.

References:

1. Behzad Razhavi, "Fundamentals of Microelectronics", Wiley, 2013.
2. J. Millman and A. Grabel, "Microelectronics", McGraw Hill, 1988 (Second Edition)
3. Thomas L. Floyd, "Electronic Devices", Prentice Hall, 2012 (Ninth Edition).
4. David A. Bell, "Electronic Devices and Circuits", Oxford University Press India, 2008 (Fifth Edition).
5. K. Mahadeven, C. Chitra, "Electrical Circuit Analysis", Prentice Hall, 2015.
6. David Báez-López, Félix E. Guerrero-Castro, "Circuit Analysis with Multisim", Morgan and Claypool, 2011.
7. NPTEL, "Basic Electrical Circuits", http://nptel.ac.in/courses/117106108/
8. NPTEL, "Circuit Theory", http://nptel.ac.in/courses/108102042/

SIGNALS AND SYSTEMS

ECE21RXXXX	Signals and Systems		L	T	P	X	C
			2	0	0	3	3
Pre-requisite	**:**	Basic Mathematics at I year level / Equivalent					
Course Category	**:**	Programme Core					
Course Type	**:**	Theory					

Course Description:

Signals and system course introduces the fundamental principles of signals and system analysis. These concepts form the building blocks of modern digital signal processing, communication, and control systems.

Course Objective:

Make Students to analyse different types of signals and their associated systems with different types of transforms to combine in prototypical tasks of signal processing

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Understand the characteristics of signals and system in continuous and discrete time
- **CO2 :** Apply the continuous and discrete time transforms on the given signal
- **CO3 :** Analyse the response of linear, time-invariant systems in time and frequency domain using appropriate transforms
- **CO4 :** Understand the process of sampling and the effects

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	H	L		L			L	L				H	L	
CO2	H	H	M	L	L								L	L	
CO3	H	H	H	L	L							L	H	M	
CO4	L	L	L										L		

Course Topics:

Unit 1: Signals, System

Signals- Classification of Signals- Transformation of independent/ dependent variables - Basic Elementary signals- Analog to Digital conversion- Sampling, Quantization-Concept of frequency in Continuous time and Discrete time signals- System- Classification of systems- Analysis of discrete Linear time invariant system

Unit 2: Frequency Analysis of Signals

Frequency analysis of discrete time signals-Fourier transform and its properties- Continuous time Fourier transform (CTFT) and its properties- Discrete time Fourier transform (DTFT) and its properties- Discrete Fourier Transform (DFT) and its properties - Fast Fourier transform (FFT)- Convolution of Discrete time signal- Correlation of discrete time signal.

Unit 3: Laplace Transform

Unilateral LT – Bilateral LT- Laplace domain analysis- ROC, Inverse LT, Solving differential equation with initial conditions, Solution to differential equations and system behaviour.

Unit 4: Z-Transform and Realization

Unilateral and Bilateral Z transforms and its properties - region of convergence- Inverse Z transform: Power series expansion and Partial fraction methods- Z domain analysis, Solution to difference equation- Frequency domain characteristics of LTI system- Realization of structures for DT systems -Direct form-I- Direct form II--Parallel-Cascade forms - Case study / Real time application

Unit 5: Sampling and Reconstruction of Signal

Sampling: Sampling theorem, Effect of under sampling. Quantization-coding. Digital to Analog conversion- Reconstruction of signal- sampling with a zero-order hold - DSP applications and Advantages

X- Component Topics:

1	(i)Representation of CT and DT signal (ii)Representation of Elementary signal. (iii)To determine odd and even component of the signal
2	Representing of Time shift, Time reversal, Time scaling of both CT and DT signal
3	Analysis of discrete Linear time invariant system using impulse and step response
4	Representation of Magnitude and Phase spectrum using DFT and FFT.
5	Performing the Convolution and Correlation of the given sequences
6	Determining X(s) the LT of the given signal and finding ROC
7	To find x(t)from X(s) for the various ROC conditions.
8	Solving the differential equation using Laplace transform
9	Determining z-transform of the given sequence.
10	To find x(n) from X(z) for various ROC conditions.
11	Solving the given difference equation using z-transform.
12	Analysing the effect of aliasing if it is not bandlimited.
13	Reconstruction of signal from the bandlimited signals.
14	(i)) Record voice and display the waveform. (ii) Add noise to the signal and display the frequency spectrum. (iii) Simple project

Textbooks:

1. Alan V. Oppenheim Alan S. Willsky, “Signals and Systems”, Pearson, India, 2015 (Second Edition).

2. John G. Proakis and Dimitris G Manolakis, “Digital Signal Processing: Principles, Algorithms, and Applications”, Pearson, India, 2007 (Fourth Edition).
3. https://nptel.ac.in/courses/108/104/108104100/

References:

1. B.P. Lathi and Roger Green, “Linear Systems and Signals”, Oxford University Press U.S, 2017 (Third Edition).
2. Simon Haykin, Barry Van Veen, “Signals and Systems”, Wiley India, 2008 (2nd Edition).
3. Tarun Kumar Rawat, “Signals and Systems”, Oxford University Press, 2010.
4. Oktay Alkin, “Signals and Systems: A MATLAB® Integrated Approach”, CRC Press, 2014.
5. Shaila Dinkar Apte, Rajarshi Shahu, “Signals and Systems: Principles and Applications”, Cambridge University Press, 2016.
6. https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-ee07/
7. https://learning.edx.org/course/course-v1:IITBombayX+EE210.1x+1T2018a/home

CONTROL SYSTEMS

ECE21RXXX	Control Systems	L	T	P	X	C
		2	0	0	3	3
Pre-requisite	**:**	Basic Mathematics at I year Level / equivalent				
Course Category	**:**	Programme Core				
Course Type	**:**	Theory				

Course Description:

This course is to explore the modelling of linear dynamic systems via differential equations and transfer functions utilizing state-space and input-output representations; analysis of control systems in the time and frequency domains and using transfer function and state-space methods; study of the classical stability tests, such as the Routh-Hurwitz and Nyquist criterions, and design methods using root-locus plots and bode plots; and the development of control techniques based on PID, lead and lag networks, using linear state or output feedback. Optimize the control problem of both linear and non-linear system.

Course Objective:

Teach students how to analyse the control systems with the help of mathematical models. Make them to learn various methods and techniques to improve the performance of the control systems based on the requirements by analysing the stability of a system and knowing the concept of compensators and controllers.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Derive the mathematical models of control systems
- **CO2 :** Apply block diagram reduction and signal flow graph techniques to simplify the given control system.
- **CO3 :** Analyse the transient and steady state performances of control systems
- **CO4 :** Investigate the stability of a system using time domain and frequency domain techniques
- **CO5 :** Design different compensators and controllers in time/frequency domain as per the requirements

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	L				L	L						H		
CO2	H	H	M		L	L	L	L					M	M	
CO3		H			M								H	L	
CO4		H			L	L	L	L	L				H	L	
CO5		M	H										H	M	

Course Topics:

Unit 1: Control System Basics and Modelling

Mathematical Preliminaries (Laplace Transform), Components of a control system, open loop and closed loop control systems, Classification of control systems, Feedback system fundamentals, Dynamic system models, Forms of dynamic system model, modelling of mechanical systems, electrical systems, and electro-mechanical systems, Mathematical forms, Switching between different forms

Unit 2: Dynamic Response

System response determination using Differential equation model and Transfer function model, First order and Second order systems, System modelling diagrams (Block diagram model, Block diagram reduction, Mason's rule, Signal flow graph), Effect of poles, zeros and additional poles, Stability (BIBO, Routh's Stability criterion)

Unit 3: Feedback Analysis, Root-Locus Design

Feedback analysis: Basic equations of control (Stability, Tracking, Regulation, Sensitivity), Steady-state tracking and System type, Industrial Controllers (On-Off Controller, P, PI, PD, PID Controllers), Tuning of PID controllers, Root-locus design methods: Root locus basics, Constructing the root-locus, Design using dynamic compensators (Lead compensation, Lag compensation)

Unit 4: Frequency Response Design Method

Gain-phase relationship, Bode plot, Frequency response, Magnitude and Phase Angle (Constant factor, A simple pole factor, A simple zero factor, An integrator factor, A derivative factor, A complex pole factor). Neutral stability, The Nyquist stability criterion, Stability margins, Closed-loop frequency response, Compensation (PD Compensation, Lead Compensation, PI Compensation, Lag Compensation, PID Compensation)

Unit 5: State Space Design Method, Case Studies

Block diagram and State-space, State-transition matrix, and System response, Switching between different forms. System controllability and observability, Introduction to Digital Control Systems and Networked Control Systems (Definition and Components),

Digital Control system Case study: Satellite control using a microprocessor with state variable. Feedback Analysis Case studies: DC motor speed control (open – loop, close-loop), DC motor position control (open - loop) [Input – Output form, Transfer function, Block diagram form, State-variable form]

X- Component Topics:

1 Tutorial on examples illustrating open loop and closed loop systems
2 Tutorial on System models: Satellite attitude control model analysis using Simulink
3 Tutorial on Transfer function of systems: Transfer function of input voltage to motor current in a motor power amplifier
4 Tutorial on System response: Transfer function and step response of DC motor control using MATLAB
5 Tutorial on Block diagram: Block diagram reduction using MATLAB
6 Tutorial on System type: System Type for a DC Motor Position Control

7	Tutorial: Motor speed PID control, Satellite Attitude PD and PID Control, Motor position PI control using MATLAB
8	Tutorial: Root locus determination and Bode plot using MATLAB
9	Tutorial: Nyquist diagram using MATLAB
10	Tutorial: Lead compensation using MATLAB
11	Tutorial: State equations analysis using MATLAB
12	Design, and Simulation of Temperature Controlled Circuit using Op-Amp as On-Off, P and PI Controllers

Textbooks:

1. Arthur G.O. Mutambara, “Design and Analysis of Control Systems”, CRC Press, 1999
2. Subathra, S. Sesadhri, “Control Systems”, Vijay Nicole India, 2012 (Third Edition)
3. https://nptel.ac.in/courses/107/106/107106081/

References:

1. Nagrath, I.J and Gopal, Madan, “Control Systems Engineering”, New Age International, 2017 (Sixth Edition)
2. M. Gopal, “Control Systems: Principles and Design”, McGraw Hill India, 2012 (Fourth Edition)
3. A. Ambikapathy, “Control System”, Khanna Publishing, 2019
4. S. Salivahanan, “Control Systems Engineering”, Pearson India, 2015
5. A. Anand Kumar, “Control Systems”, PHI, 2014 (Second Edition)
6. https://www.edx.org/course/introduction-to-control-system-design-a-first-look
7. https://www.tutorialspoint.com/control_systems/index.htm

ANALOG INTEGRATED CIRCUITS

ECE21RXXX		Analog Integrated Circuits	L	T	P	X	C
			3	0	2	0	4
Pre-requisite	**:**	Electronic Circuits					
Course Category	**:**	Programme Core					
Course Type	**:**	Integrated Course					

Course Description

This course introduces the theoretical and circuit aspects of Op-amp, which is the backbone for the basics of linear integrated circuits. Operational amplifier is one of the most important basic blocks of any basic integrated electronic system. It has been in use for many years, and it is used in wide range of application such as linear, non-linear, mathematical interfacing, communication, and control system. The main objective of this course is to introduce the characteristics, analysis, working principle and applications of Operational Amplifiers.

Course Objective:

To make students known about blocks, characteristics of operational amplifier and hence they can design analog integrated circuits using Op-amp in linear and nonlinear domain.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Analyse the various Op-Amp based Analog Integrated Circuits and gather the DC and AC characteristics of operational amplifiers.
- **CO2 :** Design the op-amp circuits for linear and non-linear applications.
- **CO3 :** Design signal generators and voltage regulators using analog ICs.
- **CO4 :** Design active filters, timer circuits and data converters for the required applications using linear ICs.
- **CO5 :** Analyse the different data converters and transconductance amplifier.
- **CO6 :** Work as a team or individual efficiently to operate electronic test equipment and hardware/software tools for the creation, evaluation and troubleshooting of Op-Amp based Circuits by applying the knowledge on them with an understanding of their limitations and impact on society, environment.
- **CO7 :** Communicate the technical information related to designed electronic circuits by means of oral and written reports.

Mapping of Course Outcomes:

CO /	PO												PSO		
PO	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	H											H		
CO2	H	H	H				L					L	H		L
CO3	H		H				L					L	H		L
CO4	H	M	H				L					L	H		L

CO5	H	H		M								L	H		L
CO6				M	H	H	H		H			M		H	L
CO7									M	H	H			M	M

Course Topics

Unit 1: Op-Amp Internal Circuit

Differential amplifier (BJT and FET) - Current Mirror (BJT and FET): Wilson current source and Widlar current source - Op-Amp design: Op-amp: symbol, terminals, packages and specifications, Block diagram Representation of op-amp, Ideal op-amp, and practical op-amp - DC and AC Characteristics - IC 741, and IC L082 features - Op-Amp parameters - Frequency compensation - Open loop, and closed loop configurations.

Unit 2: Applications of Op-Amp - Amplifiers

Basic Op-Amp circuits: Inverting and Non-inverting voltage amplifiers - Voltage follower, summing amplifier - Linear Applications: Instrumentation Amplifiers, V-to-I and I-to-V converters, Differentiators, and Integrators - Non-linear Applications: Precision Rectifiers, Isolation amplifier, V to F and F to V converters, Sample and Hold circuit.

Unit 3: Applications of Op- Amp – Oscillators, Voltage Regulator ICs

Astable and Monostable Multivibrator - Schmitt trigger - Positive feedback and conditions for oscillations - RC-Phase shift, Wein Bridge - Colpitts, and Hartley Oscillators - Voltage Regulator: Series op amp regulator, IC voltage regulator - 723 general purpose regulators.

Unit 4: Filters and Timer

Active filters: Low pass, High pass, Band pass and Band reject filters - First and second order design guidelines - 555 Timer: Functional diagram - Monostable and Astable operation - PLL: Basic principle and Applications - VCO: Basic principle and Applications.

Unit 5: Data Converters, Operational Transconductance Amplifier

Data converters (Analog to Digital Conversion, Digital to Analog Conversion) - Weighted resistor, R-2R, and Inverted R-2R DACs - Flash, Counter type and Successive approximation ADCs - DAC and ADC specifications - Commercial ADC and DACs - Operational Transconductance Amplifier (OTA): Basics, Structure and Applications.

Laboratory Experiments:

1 Design of FET/BJT Differential amplifier

2 Study of TI Analog System Lab Kit

3 Obtain the gain bandwidth product of the inverting amplifier and the non-inverting amplifier from the frequency response using TI Analog System Lab Kit.

4 Design an instrumentation amplifier using two OP-Amps with a controllable differential-mode gain and determine the CMRR using TI Analog System Lab Kit.

5 Apply a sine wave to the integrator and find magnitude and phase response using TI Analog System Lab Kit.

6 Design a Water Level Alarm or LED flasher as an application of Op-Amp multivibrator using TI Analog System Lab K

7 Design an oscillator (RC Phase Shift / Wein Bridge) using Op-amp of TI Analog System Lab Kit.

8	Design of Active filters using Op-amp of TI Analog System Lab Kit.
9	Design a precise Water Level Alarm or LED flasher using 555-timer.
10	Design Signal Generator as a VCO Application using Op-amp of TI Analog System Lab Kit.
11	Design of Weighted Resistor DAC for porting out analog data in a IoT system using Op-amp.
12	Design of Successive approximation ADC for sensor data acquisition using Op-amp.

Textbooks:

1. S Salivahanan, V. S. Kanchana Bhaaskaran, “Linear Integrated Circuits”, McGraw-Hill India, 2018 (Third Edition)
2. Paul Horowitz, Winfield Hill, “The Art of Electronics”, Cambridge University Press India, 2015 (Third Edition)
3. https://nptel.ac.in/courses/117/106/108106105/#

References:

1. D. Roy Choudhury, Shail B. Jain, “Linear Integrated Circuits”, New Age, 2018 (Fifth Edition)
2. Sergio Franco, “Design with Operational Amplifiers and Analog Integrated Circuits”, McGraw Hill India, 2016 (Fourth Edition)
3. Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, Robert G. Meyer, “Analysis and Design of Analog Integrated Circuits”, Wiley India, 2015
4. Behzad Razavi, “Design of Analog CMOS Integrated Circuits”, McGraw Hill India, 2017 (Second Edition)
5. https://www.coursera.org/lecture/commercialization-of-innovation-activity-results/industrial-designs-and-integrated-circuits-nuFf9
6. Texas Instruments (Ron Mancini – Editor in Chief), Op amps for everyone, e-book (http://www.ti.com/lit/an/slod006b/slod006b.pdf)

ANALOG AND DIGITAL COMMUNICATION

ECE21RXXXX	Analog and Digital Communication	L	T	P	X	C
		3	0	2	0	4
Pre-requisite	:	Signals and Systems / equivalent				
Course Category	:	Programme Core				
Course Type	:	Integrated Course				

Course Description:

This course provides the ideas and techniques fundamental to analog and digital communication systems, related to transmission of information over wired and wireless communication channels. The course focuses on developing and understanding of the principles and techniques of analog and digital modulation. Communication transmitter and receiver design techniques are discussed for different transmission conditions. Noise and error analysis techniques are also introduced. Emphasis is placed on system design goals and the need for trade-offs among basic system parameters such as signal-to-noise ratio (SNR), probability of error and bandwidth expenditure

Course Objective:

The course will provide knowledge of basic electronic communication process for solution of engineering problems

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Compare various analog, digital modulation/demodulation techniques and select the necessary technique for an application
- **CO2 :** Apply the sampling theorem, encoding, and multiplexing in communication systems.
- **CO3 :** Analyse the concepts of spread spectrum and information coding in digital communication system
- **CO4 :** Describe the techniques like multiple access for modern communication systems such as cellular wireless systems
- **CO5 :** Analyse the operation of analog and digital communication systems and measure its performance to compare experimental results in the laboratory with theoretical analysis as a team/individual effectively following safety norms and ethics.
- **CO6 :** Document the technical information related to communication engineering principles and systems efficiently

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3

CO1	H	L										L	H		L
CO2	L	H	L										H		
CO3	H	L											H		
CO4	L	H	L									L	H		L
CO5	L	L	H	H	H	L	L	H					L	H	L
CO6								L	H	H				H	L

Course Topics:

Unit 1: Analog Communication

Overview of communication systems, Frequency bands, need for modulation, Double-sideband AM; Double-Sideband Suppressed Carrier AM, SSB, VSB AM (Definitions, Modulation and De-modulations, Bandwidths, Generations and Receivers, Comparisons) - Phase and frequency Modulation (Definitions, Modulation and De-modulations, Bandwidths, Generations and Receivers, Comparisons), Pre-emphasis and de-emphasis - Applications: FM Radio and Analog Broadcast TV

Unit 2: Pulse Modulation, Pulse Code Modulation

Base band system, Sampling and Quantization, Encoding - Pulse Modulation: Pulse Amplitude Modulation, Pulse Width Modulation, Pulse Position Modulation (Definition, Modulation, Demodulation, Applications, Advantages and Disadvantages) - Pulse Code Modulation, DPCM, Delta modulation,

Line coding, Data encoding techniques, Multiplexing (TDM and FDM), Applications: Digital Multiplexing in Telephone

Unit 3: Digital Modulation

Amplitude Shift Keying, Frequency Shift Keying, Phase Shift Keying, Binary PSK (Definition, Mathematical Representation, Generation and Reception) - Quadrature PSK, Quadrature Amplitude Modulation, 8-QAM, 16-QAM (Definition, Mathematical Representation, Generation and Reception) - Optimum Receiver, Coherent and Non-coherent detections, ISI and Eye diagrams, Comparison of Digital Modulation schemes

Unit 4: Random Process, Information Coding, Spread Spectrum Techniques

Random process: realizations, sample paths, discrete and continuous time processes, examples, Probabilistic structure of a random process; mean, autocorrelation and auto covariance functions, Entropy, Source encoding theorem, Shannon Fano coding, Huffman coding - Mutual information, channel capacity, Error Control Coding, linear block codes, cyclic codes - Fundamentals of Spread Spectrum Techniques: DSSS, FHSS, Examples of spread spectrum with Wi-Fi and Bluetooth, Applications: Broadband Modems (xDSL modems)

Unit 5: Multiple Access Techniques, Mobile Communication Basics

Fundamentals of Multiple Access Technologies, CDMA of DSSS, OFDMA communication basics - List and comparison of mobile communication generations, GSM Fundamentals: Terms in GSM, Cellular Concept, Spectrum Range, Modulation, and access techniques - 5G Mobile Technology Basics**:** Spectrum Range, Modulation, and access techniques

Laboratory Experiments:

1 Study of Spectrum Analyser and AM/FM Signal Generator
2 Study of NI DATEx experimental add-in module with soft front panel control (NI LabVIEW)
3 Modulate and Demodulate Analog Broadcast TV signals using trainer kit (or) Breadboard circuit.
4 Modulate and Demodulate FM Radio Broadcasting signals using Trainer Kit (or) Breadboard circuit
5 Sample and reconstruct audio signals using NI DATEx kit
6 Encode and Decode data by PCM with NI DATEx kit
7 Generate PWM signals used for motor control using trainer kit (or) IC 555 and IC 741 circuit (Breadboard / Simulation)
8 Multiplex digital signals and observe the waveforms using trainer kit or IC 741 circuit
9 Implement Delta modulation using trainer kit and verify the working.
10 Encode and decode line coding using trainer kit
11 Modulate and demodulate the data with ASK/FSK/BPSK technique using IC 741 (Breadboard / Simulation)
12 Determine SNR and Eye Diagram using LabVIEW
13 Spread Spectrum - DSSS modulation and demodulation using NI DATEx kit

Textbooks:

1. B.P. Lathi, Zhi Ding and Hari Mohan Gupta, "Modern Digital and Analog Communication", Oxford University Press, India, 2017 (Fourth Edition)
2. B. Preetham Kumar, "Communication Systems Laboratory", CRC Press, India, 2015
3. https://onlinecourses.nptel.ac.in/noc19_ee46/preview

References:

1. Blake, "Electronic Communication Systems", Thomson Delmar Publications, 2018
2. H. Taub, D L Schilling and G Saha, "Principles of Communication", Pearson, 2017 (Third Edition)
3. John G. Proakis, Masoud Salehi, "Communication Systems Engineering", Pearson, 2016
4. Martin S. Roden, "Analog and Digital Communication System", Prentice Hall of India, 2017 (Third Edition)
5. B. Sklar, "Digital Communication Fundamentals and Applications", Pearson, 2017 (Second Edition)
6. Rappaport T.S, "Wireless Communications: Principles and Practice", Pearson, 2017 (Second Edition)
7. https://nptel.ac.in/courses/117/101/117101051/

MICROCONTROLLERS AND INTERFACING TECHNIQUES

ECE21RXXX	Microcontrollers and Interfacing Techniques	L	T	P	X	C
		3	0	2	0	4

Pre-requisite	**:**	Digital electronics and system design / equivalent
Course Category	**:**	Programme Core
Course Type	**:**	Integrated Course

Course Description

This course deals with fundamental concepts of AVR microcontrollers and microprocessors. This course also deals with High level Programming concepts of AVR microcontrollers such as data transfer, ADC, DAC, Sensor, and I/O interfacing. Further the course illustrates the Assembly level Programming concepts of microcomputer systems for data transferring process.

Course Objective:

To develop an in-depth understanding of the operation of microprocessors and microcontrollers and its interfacing techniques.

Developing of assembly and High-level programs for performing the real time applications related to microcontrollers.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Describe the basics of Microcontrollers systems and its types.
- **CO2 :** Explain the basic of AVR programming concepts.
- **CO3 :** Analyse the AVR data conversions and data acquisition concepts.
- **CO4 :** Apply the AVR programming concepts for timer and serial communication systems.
- **CO5 :** Summarise the microcomputer system basics.
- **CO6 :** Use the hardware and software tools to write, compile, run, test, and document the microcomputer program for the given requirements as a team/ an individual following the ethics and norms.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M											H		
CO2	H	M											H		
CO3	H	M	L									L	H		L
CO4	H	M	L									L	H		L
CO5	H	L											H		
CO6			M	H	H	L	L	H	H	H		M	H	M	M

Course Topics

Unit 1: Microcontroller Based System Basics

Microcontroller Basics - RISC vs. CISC, Vonneuman and Harvard architectures, Hardware vs. Software vs. Firmware, Machine vs. Assembly vs. High level languages, Microcontroller Based System Components, Embedded system design and development process (Hardware overview, UML activity diagram, Software modelling analysis and design, Implementation and Testing tools), Case study: A Traffic Light Control as Embedded System Modelling and Design, Commercial microcontrollers list (single bit to 64 bits). ATMEL family of microcontrollers, ATMEGA 328: Hardware features, Memory, Port systems, Internal systems, ATMEGA 2560: Hardware features, Memory, Port systems, Internal systems.

Unit 2: AVR Microcontroller Programming Basics

Data types and time delays in C, I/O Programming in C, Logic operations in C, Memory allocation in C -Digital input and switch debouncing, Keypad Scanning C, Digital output, LCD Hardware and Software, DC Motor speed and direction control.

Unit 3: AVR ADC and Interrupt system

Sensor and Analog information, ADC and DAC systems of ATMEGA 328, ATMEGA 2560 and their programming in C, Interfacing of Sensors and Signal conditioning circuits with microcontrollers, Relays and Opto-isolators hardware and interfacing, Data acquisition and control using microcontrollers. Interrupt systems of ATMEGA 328, ATMEGA 2560 and their programming in C

Unit 4: AVR Timing subsystem and Serial communication subsystem

Timer system applications, ATMEGA 328, ATMEGA 2560 timer systems, Timer system programming in C- Serial USART, SPI, TWI of ATMEGA 328, ATMEGA 2560 and their programming Embedded systems case studies using AVR: Automated Cooling system, Submersible Robot.

Unit 5: Microcomputer System Basics

Commercial microprocessors list (single bit to 128 bits), Microcomputer system ALU, Register Unit, Control Unit), Various Registers in CPU, System Bus (Address bus, data bus, control bus), Memory types and Memory organisation, Microcomputer Input/Output (I/O), methods, Data transfer scheme, Classification of digital system buses (Link buses, Expansion slot buses, I/O buses), Fetch and Execute cycles, addressing modes, instruction set, subroutine.

Laboratory Experiments:

1 Toolchain for programming AVR microcontrollers: Setting up Microchip (Atmel) Studio to program in C;
2 Simulate and Debug using Microchip (Atmel) Studio (Viewing Registers, Ports)
3 Study of Arduino UNO/Mega Pin mapping.
4 Flash an LED by C Programming in Atmel Studio and AVR
5 Interface Pushbutton and LED by C Programming in Atmel Studio and AVR; Message on an LCD by C Programming in Atmel Studio and AVR

6 Read an analog signal (a varying voltage derived using a potentiometer or LDR) and display it on an LCD – Study of ADC, DAC by C Programming in Atmel Studio and AVR.

7 Interfacing a simple sensor and controlling a parameter – Data acquisition and control by C Programming in Atmel Studio and AVR

8 Multiplexing seven segment LED (4-digit) displays – Interrupt study by C Programming in Atmel Studio and AVR

9 Digital Clock (HH:MM) Display – Timer study by C Programming in Atmel Studio and AVR

10 Hello world Program –Study of Assembly Programming and directives using NASM/ TASM/ MASM

11 Program to study registers (NASM / TASM / MASM)

12 Program to study addressing modes (NASM/ TASM/ MASM)

Textbooks:

1. Steven F. Barrett, "Arduino Microcontroller Processing for Everyone", Morgan and Claypool Publishers, 2013 (Third Edition).
2. Philippe Darche, "Microprocessor (2 to 4)", Wiley – ISTE US/U, 2020.
3. https://www.udemy.com/course/programming-for-avr-microcontrollers/

References:

1. Kai Qian, David den Haring, and Li Cao, "Embedded Software Development with C", Springer US, 2009.
2. Steven F. Barrett and Daniel J. Pack, "Microcontrollers Fundamentals for Engineers and Scientists", Morgan and Claypool Publishers, 2006.
3. Muhammad Ali Mazidi, Sarmad Naimi and Sepehr Naimi, "The AVR Microcontroller and Embedded Systems: Using Assembly and C", Pearson India, 2014.
4. Steven F. Barrett and Daniel J. Pack, "Microchip AVR® Microcontroller Primer: Programming and Interfacing", Morgan and Claypool Publishers, 2019.
5. https://www.tutorialspoint.com/assembly_programming/index.htm
6. https://www.tutorialspoint.com/microprocessor/microcontrollers_overview.htm

ENGINEERING ELECTROMAGNETICS

ECE21RXXXX	Engineering Electromagnetics	L	T	P	X	C
		3	0	2	0	4

Pre-requisite	**:**	Basic Physics at I year Level / equivalent
Course Category	**:**	Programme Core
Course Type	**:**	Integrated Course

Course Description:

The course is a fundamental course where students will be learning about the concepts of vector calculus, electrostatics and magnetostatics, the fundamental laws that govern Maxwell's equations. Electromagnetic explains universal concepts in three-dimension real world, i.e., electromagnetic wave propagation in free-space. The course also introduces various effects of EMI/EMC with standard for describing their properties. The course ends with a few insights on applications of EM waves.

Course Objective:

To expose the students to the rudiments of electromagnetic theory and wave propagation essential for subsequent courses on transmission lines, waveguides, microwave engineering, antennas, and wireless communication.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Apply vector calculus concepts along with physical principles and properties to effectively solve problems encountered in everyday life, further study in science, and in the professional world related to electric field.
- **CO2 :** Characterise the variations in Magnetic field by the knowledge gained from Ampere's circuital law.
- **CO3 :** Interpret phasor Maxwell's equations in differential and integral forms, in time domain from the electrodynamics concept.
- **CO4 :** Analyse the boundary conditions between the two different mediums in the magnetic field and apply the concepts of uniform plane wave propagation for the time varying electric and magnetic fields.
- **CO5 :** Explain EMC regulation and methods of eliminating interferences
- **CO6 :** Acquire data from computer simulations to explore electromagnetic principles, effectively communicate the results as a team/individual following the safety procedures and ethics in the laboratory.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	H										H	H		M
CO2	H	H										H	H		M

CO3	H	M										H	H		L
CO4	H	M				L						H	H		L
CO5	H	L				L						H	H		L
CO6		M	H	H	H	H		H	H	H				M	L

Course Topics:

Unit 1: Electrostatics

Vector analysis, Cartesian, Cylindrical and Spherical coordinate systems, Relationship between the coordinate systems, Properties of coordinate system - Coulomb's law and its applications, Electric field intensity, Electric flux densities for various charge distributions such as line, surface, and volume - Gauss's law and its applications - Electrostatic potential, Divergence theorem - Convection and Conduction current - Electric field in free space, conductors, and dielectrics, Electrostatic boundary value problems: Poisson's and Laplace's equations and solutions

Unit 2: Magnetostatics

Magnetic field intensity - Bio Savart's law - Ampere's circuit law - Magnetic flux and Magnetic flux density, Magnetic flux density in free space, conductor, and magnetic materials - Magnetic force, Magnetic Vector potential - Stroke's theorem.

Unit 3: Electromagnetics

Faraday's Law - Maxwell's equations in point form and integral form for steady fields - Boundary conditions using Maxwell's equations - Retarded potentials.

Unit 4: Uniform Plane Wave

Uniform plane wave - Wave polarization - Wave propagation in free space, dielectrics and conducting medium - Power flow and Poynting vector - Plane Waves at a Media Interface, Plane wave in arbitrary direction - Plane wave propagation at general directions, plane wave reflection at oblique incidence angles.

Unit 5: Applications

EMI / EMC, EMI Sources - Effects of EMI – Testing Methods for EMI/EMC, Methods to suppress EMI-Grounding and shielding. EMC standards - Practical issues of EMI/EMC non compliances, biological effects of EMI / EMC – ESD - EMP

Applications of EM: RADAR - Fibre Optic Communications - Remote Sensing.

Laboratory Experiments:

1. Represent vectors in various Coordinate system using MATLAB; and Sketch the Surface in Cartesian Coordinates, Cylindrical Coordinates and Spherical Coordinates using MATLAB.
2. Translate vectors between coordinate systems using MATLAB.
3. Find electric flux of charged surfaces and electric field due to point charges, line, surface, and volume charge density using MATLAB.
4. Find Divergence and Curl for a Current Carrying Wire using MATLAB
5. Find the magnetic field from the current carrying conductors using MATLAB
6. Find and plot the normalized vectors E and D in anisotropic Dielectric medium using MATLAB.

7	Visualise Maxwell's equations using MATLAB.
8	Display the charge distribution of Parallel plate capacitor computed by Method of moments using MATLAB
9	Find the Poynting vector of a standing wave and compute the power of plane waves from the pointing vector using MATLAB.
10	Compute dielectric-dielectric boundary conditions for arbitrarily positioned (Oblique) boundary between medium 1 and 2 using MATLAB
11	Analyse EMI/EMC of cables using MATLAB.
12	Design, simulate and analyse a basic monostatic pulsar RADAR system using MATLAB.

Textbooks:

1. William H. Hayt, John A. Buck, Jaleel M. Akhtar, "Engineering Electromagnetics", McGraw Hill India, 2020 (Ninth Edition).
2. Mathew O Sadiku, "Elements of Electromagnetics", Oxford University Press, 2014 (Sixth Edition).
3. http://nptel.ac.in/courses/108106073/41

References:

1. Griffiths, David J, "Introduction to Electrodynamics", Pearson India, 2015 (Fourth Edition),
2. Dikshitulu K. Kalluri, "Electromagnetic Waves, Materials, and Computation with MATLAB", CRC Press, US, 2018 (Second Edition).
3. Edward C. Jordan, Keith G. Balmain, "Electromagnetic Waves and Radiating Systems", Pearson India, 2015(Second Edition).
4. Constantine A. Balanis, "Advanced Engineering Electromagnetics", Wiley US, 2012 (Second Edition)
5. Saroj K. Dash, Smruti R. Khuntia., "Fundamentals of Electromagnetic Theory", Prentice Hall, 2011 (Second Edition)
6. R K Shevgaonkar, "Electromagnetic Waves", McGraw Hill India, 2006.
7. https://www.edx.org/xseries/mitx-introductory-electricity-and-magnetism
8. https://www.coursera.org/specializations/electrodynamics
9. https://www.tutorialspoint.com/electromagnetics_theory/index.asp

TRANSMISSION LINES AND WAVEGUIDES

ECE21RXXXX	Transmission Lines and Waveguides	L	T	P	X	C
		2	0	0	3	3
Pre-requisite	**:**	Engineering Electromagnetics / equivalent				
Course Category	**:**	Programme Core				
Course Type	**:**	Theory				

Course Description:

Transmission Lines and Wave guides is a quintessential academic discipline. It includes abstract and challenging mathematical concepts PDE of vector fields and the curl operator. It is a coherent body of material with a pleasing structure and a natural pedagogical progression from circuits and statics to fields and waves. It connects mathematics and physics and is used in a wide variety of engineering applications, including digital systems, bioengineering, power and energy systems, optics and optoelectronics, high-frequency devices and circuits, microwave systems, remote sensing, wireless communications, and medical imaging.

Course Objective:

The Course is designed to use Experiential learning that helps with the promotion of visualization, experimentation, and interpretation skills and in turn facilitates "an effective construction of knowledge" in Transmission Lines and Wave guides. It is well supported with Active Learning and Project based learning to explore the intuition generated from the students. At the end of the course student will be able to design, develop and trouble shoot transmission line problem with solutions.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Understand the types of transmission lines, features, and structure.
- **CO2 :** Analyse the transmission lines and their parameters using the Smith Chart
- **CO3 :** Analyse different wave guides and classify the guided wave solutions -TE, TM, and TEM
- **CO4 :** Analyse and design rectangular, circular wave guides and evaluate the resonance frequency of cavity resonators and the associated modal field.
- **CO5 :** Apply the knowledge in planar transmission lines with many applications.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	L													
CO2		H							L	M	H	M	M		H
CO3		H	M										M	H	L
CO4		H	M						L	M	H		M	H	H
CO5		L	M									M	M	H	L

Course Topics:

Unit 1: Transmission Lines

Characteristic impedance, Primary and secondary Constants, general solution of the transmission line, The Two standard forms for voltage and current of a line terminated by an impedance, wavelength and velocity of propagation, waveform distortion. Types of Transmission Lines: distortion less transmission line, Lossless transmission lines. Reflection coefficient, standing wave ratio, return loss, transmission coefficient, insertion loss, standing wave pattern, input impedance. Reflection on a line not terminated by Zo, transfer impedance, Open-circuited and short-circuited lines, T and ∏ Section equivalent to lines.

Unit 2: Impedance Matching

Lumped element matching, the Quarter wave line and the half wave line, Impedance matching by stubs: Single stub and double stub matching, Impedance and admittance chart, Measurement of parameters using Smith Chart, Impedance transformation to reflection coefficient, Single and double stub matching using Smith chart

Unit 3: Guided Waves

Waveguide: working principle, applications, types, Transmission Lines vs. Waveguides, RF waveguides vs. Optic waveguides, Hollow Metallic vs. Dielectric waveguides. Closed vs. Open waveguides, RF waveguide properties: Propagation modes, guide wavelength, cut off wavelength, cut off frequency, wave impedance, phase constant, phase velocity, group velocity, powerband attenuation, General solutions for TEM, TE and TM waves. Attenuation of TE and TM waves in parallel plane guides.

Unit 4: Hollow Waveguides, Resonators

TE waves in Rectangular Waveguides, Impossibility of TEM waves in waveguides Dominant mode in rectangular waveguide, excitation of modes. TM and TE waves in circular waveguides, Dominant mode in circular waveguides, dominant mode in circular waveguide, excitation of modes. Microwave cavities, rectangular cavity resonators, circular cavity resonator, semicircular cavity resonator.

Unit 5: Planar Transmission Lines

Introduction to Planar Transmission lines: Strip lines, Microstrip line, slot lines, coplanar waveguide, and fin line. Microstrip lines for MIC: Field distribution, Design equations; Distributed parameters of Coaxial Transmission Line. Application of Waveguides: Microwave oven from Magnetron (source) to chamber, Feeder for dish antennas used in TV, RADAR.

X- Component Topics:

1 Understand the concept of characteristic impedance and reflection coefficient - tutorial problems using MATLAB; Determine the primary constants for a given transmission lines - tutorial problems using MATLAB

2 Determine the characteristics impedance and primary constants for distortion less and lossless transmission lines using MATLAB tutorial problems.

3 Determine the relation between reflection coefficient and VSWR using MATLAB tutorial problems.

4	Measure the standing waves in dissipation less line using MATLAB tutorial problems.
5	Determine parameters like wavelength, velocities and VSWR using MATLAB tutorial problems.
6	Determine stub length and stub distance and design using smith chart tutorial problems using MATLAB.
7	Determine stub length and stub distance and design using smith chart tutorial problems using MATLAB.
8	Study about stub matching using MATLAB tutorial problems.
9	Study about terminating the ports and understand the E and H field propagation using MATLAB tutorial problems.
10	Calculate the phase constant of rectangular waveguides using MATLAB tutorial problems.
11	Determine the attenuation factor and cut-off frequency using MATLAB tutorial problems.
12	Calculate the phase constant of circular waveguides using MATLAB tutorial problems.
13	Find the cut-off frequency for dominant mode in resonator using MATLAB tutorial problems

Textbooks:

1. D. M. Pozar, “Microwave Engineering”, Wiley, 2021 (Fourth Edition: International Adaption).
2. Michael Steer, “Fundamentals of Microwave and RF Design”, North Carolina State University, 2019 (Third Edition).
3. https://nptel.ac.in/noc/courses/noc21/SEM2/noc21-ee82/

References:

1. Robert E. Collin, “Foundations for Microwave Engineering”, Wiley, 2002 (Second Edition).
2. Edward F. Kuester, “Theory of Waveguides and Transmission Lines”, CRC Press, 2021.
3. Naser Pour Aryan, “Design and Modeling of Inductors, Capacitors and Coplanar Waveguides at Tens of GHz Frequencies”, Springer, 2015.
4. Xianping Wang, Cheng Yin, Zhuangqi Cao, “Progress in Planar Optical Waveguides”, Springer, 2016.
5. https://nptel.ac.in/noc/courses/noc21/SEM2/noc21-ee83/

ANTENNAS AND RADIATION

ECE21RXXXX	Antennas and Radiation	L	T	P	X	C
		3	0	2	0	4

Pre-requisite	**:**	Engineering Electromagnetics / equivalent
Course Category	**:**	Programme Core
Course Type	**:**	Integrated Course

Course Description:

The course deals with the radiation from current elements, loops, short wires, antenna parameters, reciprocity, equivalence and induction theorems, linear antennas, antenna arrays with mathematical analysis, special antenna designs, recent antenna technologies and elements of ground wave, tropospheric and ionospheric propagation with the underlying principles of Radio wave propagation. .

Course Objective:

The main Objectives of the course are:

To develop the understanding of Antenna theory, Design parameters and equations
To develop a practical understanding of antennas and their properties.
To familiar with recent developments in antenna technology.

Course Outcomes:

At the end of the course, the student will be able to:

CO1	**:**	Review the properties and parameters of antenna, Friis equation in simple communication system consisting of transmit and receive antenna to predict its received power	Apply the pro communication received power
CO2	**:**	Characterize the near- and far-fields of the Hertzian dipole.	Analyse the nea
CO3	**:**	Articulate an antenna system, including the structure of the antenna, special characteristics, the need on the arrangement of the radiating elements in an array by applying the design principles and by selecting proper antenna type for the given specifications and environments	Design an ante characteristics, array by applyi the given speci
CO4	**:**	Describe the mechanism of the atmospheric effects on radio wave propagation	Describe the m
CO5	**:**	Discuss the research on advanced topics in antenna and summarize it in writing	Grasp the resea
CO6	**:**	Construct the antennas like Monopole, dipole, microstrip, Horn, Yagi-Uda array and LDPA using Simulation Software to meet the design objectives as a team/ individual following the ethics	Design the ante and LDPA usin design objectiv
CO7	**:**	Infer the results of measured and simulated antennas in terms of parameters with justifications and proper conclusions in oral/writing.	Interpret the res with justificatio

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3

CO1	H	H	L									L	H		L
CO2	H	L											H		
CO3	H	H				L	L					L	H	L	L
CO4	H	L										L	H		L
CO5	H	H						L		M		H	H		H
CO6	H	H	M	M	H	L		H	H		M	H	L	M	H
CO7	H		M	M	H			M	L	H		H	L		H

Course Topics:

Unit 1: Antenna Fundamentals

Physical concept of radiation and need for Antenna, Isotropic radiation, Antenna parameters (definition only): Field Patterns, Gain and Directivity, Effective Length, Effective Aperture, Radiation Resistance, Antenna Terminal (self and mutual) Impedance, Polarization, Beam width, Beam efficiency, Frequency and Bandwidth, Radiation power density, Antenna temperature, Radiation pattern, near and far field radiation, duality theorem, reciprocity, and reaction theorems. Retarded potential, Linear dipole, Radiation from Hertz dipole, far field and near field approximation, monopole, half wave dipole antenna.

Unit 2: Antennas

Wire antennas: Loop antenna, Folded dipole antenna, Slot antennas, Microstrip antennas: Characteristics, radiation fields, feeding methods, analysis, Design of Rectangular patch and circular patch antennas, Aperture antennas: Huygens' principle, radiation from rectangular and circular apertures, Babinet's principle; Horn antennas: Sectoral and pyramidal horn antennas. Reflector antennas: Parabolic reflector, Cassegrain feed.

Unit 3: Antenna Arrays, Special Antennas

Antenna array various forms, arrays of point sources, non-isotropic but similar point sources, multiplication of patterns, Arrays of n-isotropic sources of equal amplitude and spacing (Broad-side and End-fire array cases), array factor, Array of n-isotropic sources of equal amplitude and spacing end-fire array with increased directivity, Special antennas: Broadband Antennas, Yagi Uda antenna, helical antenna, Frequency independent antennas, Log periodic dipole array, travelling wave antennas, rhombic antenna.

Unit 4: Recent Antenna Technologies

Reconfigurable antennas: types, reconfigurable technologies: mechanical movable switch, tuneable materials, semiconductor, and MEMS switches, Basic Concepts of Smart Antennas– Adaptive array antennas, Switched beam array antennas, multi-band antennas, Planar inverted-F antenna (PIFA) for mobile wireless communication devices and IoT devices, Antennas for Mobile Towers, Antennas for RFID Devices, Wearable antennas.

Unit 5: Radio Wave Propagation

Different modes of Radio Wave propagation, sky wave propagation, propagation through ionosphere. critical frequency. effects of earth's magnetic field, Effects of dielectric constant and conductivity of the ionosphere, collision frequency, virtual height, Maximum usable frequency, Skip distance, Ionospheric abnormalities, Space wave propagation, effective earth's radius, effect of earth's curvature on troposphere propagation, field strength of space or tropospheric wave, duct propagation.

Laboratory Experiments:

1 Study of antenna parameter measurement components/ Equipment RF Sources, Antenna trainer Kit, Detectors and meters and Antenna simulation software

2 Measure the antenna gain using transmitting and receiving antennas in antenna trainer kit

3	Measure the antenna radiation patterns and radiation intensity using transmitting and receiving antennas in antenna trainer kit
4	Design and simulate Quarter wave monopole antenna for walkie-talkie applications using simulation software.
5	Design and simulate half wavelength dipole antenna for FM Radio Reception using simulation software.
6	Design and simulate loop antenna used in NFC devices with a simulation software.
7	Design and simulate rectangular patch antenna for Bluetooth Application using simulation software
8	Design and Simulation of Horn antenna used to feed DTH/Dish antennas with antenna design software.
9	Design and simulate Yagi Uda antenna for TV Reception.
10	Design and Simulation of log periodic antenna used to measure EMC of devices with software.
11	Design a simple frequency reconfigurable antenna using varactor diode / PIN diode using antenna simulation software.
12	Design a multi-band (PIFA) antenna used in Mobile phones and IoT Devices with antenna simulation software.

Textbooks:

1. Constantine A. Balanis, “Antenna Theory: Analysis and Design”, Wiley, India, 2016 (Fourth Edition)
2. John Volakis, Antenna Engineering Handbook, McGraw Hill Professional, US, 2018 (Fifth Edition)
3. https://nptel.ac.in/courses/117/101/117101056/
4. http://nptel.ac.in/courses/108101092

References:

1. Warren L. Stutzman, Gary A. Thiele, “Antenna Theory and Design”, Wiley, US, 2012 (Third Edition)
2. F. B. Gross, “Smart Antennas for Wireless Communication”, McGraw-Hill., US, 2015 (Second Edition)
3. Constantine A. Balanis, “Modern Antenna Handbook”, Wiley, US, 2011
4. David A. Sanchez Hernandez, “Multiband Integrated Antennas for 4G Terminals”, Artech, London, 2008
5. John D. Kraus, Ronald J. Marhefka and Ahmad Sahid Khan, “Antennas and Wave Propagation”, McGraw-Hill, US, 2017 (Fifth Edition)
6. Harish, M. Sachidananda, “Antennas and Wave Propagation”, Oxford University Press, India, 2007
7. https://nptel.ac.in/courses/108/101/108101092/
8. https://www.tutorialspoint.com/antenna_theory/index.htm

MICROWAVE AND OPTICAL COMMUNICATIONS

ECE21RXXX	Microwave and Optical Communications	L	T	P	X	C
		2	0	0	3	3
Pre-requisite	**:**	Analog and Digital Communication / Equivalent				
Course Category	**:**	Programme Core				
Course Type	**:**	Theory				

Course Description

This course illustrates techniques of Microwave Engineering that enlightens the formulation of Scattering matrix for various microwave components and its properties, operation of solid state-based devices for microwave signal generation and illustrating different microwave measurement techniques and describes fibre optic communication to provide the basic concepts of optical fibres, light propagation, effect of losses and dispersion.

Course Objective:

- To introduce origin and characteristics of Microwave Communication
- To expose the students to the basics of signal propagation through optical fibres, fibre impairments, components and devices and system design.
- To provide a comprehensive introduction to various devices and passive components used at microwave frequencies.

Course Outcomes:

At the end of the course, the student will be able to:

CO1 : Acquire knowledge on the theory of microwave communication system and associated active components.

CO2 : Analyse microwave passive devices and semiconductor devices/components.

CO3 : Explain microwave measurements and associated techniques with equipment for understanding impact on the environment.

CO4 : Familiarize with the fundamentals of light transmission through fibre

CO5 : Implement appropriate signal processing algorithms for practical problems involving biomedical signals and systems

CO6 : Design a basic optical communication system with connectors and associated components

CO7 : Understand the working principle of microwave components, Microwave measurements, optical sources, detector, and fibres

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M											H		
CO2		H												H	

CO3		H	M				M						H	L	
CO4		H	M	H	H	M	H					H		H	
CO5		H			L		H	H	H		L			H	L
CO6		M					M	M		H				M	M
CO7		H			L		H	H	H		L			H	L

Course Topics

Unit 1: Microwave Passive Components

Impedance and equivalent voltage and currents, Impedance and admittance matrices, the transmission (ABCD) matrix, The scattering matrix, S-matrix for two port network and N-port networks, properties of S-matrix, E-plane Tee, H-plane Tee, Magic Tee, Hybrid ring, Directional coupler, circulator, and Isolator, S-matrix of microwave passive components

Unit 2: Microwave Active Components

Gunn diode, Two valley model theory, Gunn modes of operation, IMPATT diode. TRAPATT diode, Parametric devices, Manley Rowe power relations. Limitations of conventional vacuum tubes, two cavity klystron amplifier, Reflex klystron, Helix traveling wave tubes, cylindrical magnetron.

Unit 3: Microwave Communication Applications

Microwave communication systems – Direct Broadcast Satellite DBS system, Global Navigation Satellite System (GNSS), Radar systems, Radiometer system, Microwave heating, biological effects and safety, Microwave Radiation Hazards

Unit 4: Optical Fibre Fundamentals

General optical fibre communication system, mode analysis for optical propagation through fibres classification of optical fibre, single mode fibre, graded index fibre. Attenuation, absorption, scattering losses-bending losses, core, and cladding losses, Intra model dispersion, intermodal dispersion optimization of single mode fibre

Unit 5: Optical Fibre Communication System

LED's, LASER diodes, Photo detectors, Photo detector noise, Response time, double hetero junction structure, Fundamental receiver operation, preamplifiers, Front end amplifiers, digital receiver performance, probability of error, receiver sensitivity, quantum limit, Block diagram of optical fibre communication system, Point – to –Point link design, Link power budget, rise time budget

X-Component Topics:

1 Study of Z, Y and ABCD parameters by constructing T and π resistive networks in bread board and comparing theoretical parameters with experimental results.

2 Tutorial on Calculation of S-parameter data for two port and N-Port networks ($N \leq 4$)

3 Analyse S-Parameters of three port and four port using microwave experimental setup

4 Construct microwave test bench setup and find the VI characteristics of Gunn oscillator source

5 Construct microwave test bench setup and find the mode characteristics of Reflex klystron
6 Demonstration of Radar range equation calculator
7 Compare the specifications of standard microwave oven in market and study about the FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields
8 Determination of Numerical Aperture for Optical Fibres
9 Measurement of Connector and Bending Losses; Measurement of Attenuation in Fibres using kit.
10 Analysis of effect of dispersion using OPTSIM simulation.
11 DC characteristics of LED and PIN Photo Diode.
12 Construct a photo detector circuit using Op-Amp IC 741 and analyse its performance
13 Construct a Fibre Optic Analog and Digital Link, study its characteristics using OFC Kit and calculate the link power budget.

Textbooks:

1. Annapurna Das and Sisir K Das, "Microwave Engineering", McGraw Hill India, 2020 (Fourth Edition).
2. Govind P. Agrawal, "Fiber-Optic Communication Systems", Wiley, 2021 (Fifth Edition).
3. www.nptelvideos.in/2012/12/advanced-optical-communication.html

References:

1. Ahmad Shahid Khan, "Microwave Engineering Concepts and Fundamentals", CRC Press, 2014.
2. R. Srinivasa Rao, "Microwave Engineering", PHI, 2016 (Second Edition).
3. Sushrut Das, "Microwave Engineering", Oxford University Press India, 2014.
4. Vivekanand Mishra, Sunita P. Ugale, "Fiber-Optic Communication: Systems and Components", Wiley, 2017 (As per AICTE).
5. John M. Senior, "Optical Fiber Communications: Principles and Practice", Pearson, 2014 (Third Edition).
6. M. Sathish Kumar, "Fundamentals of Optical Fibre Communication", PHI, 2014 (Second Edition).
7. https://www.edx.org/course/fiber-optic-communications
8. https://www.tutorialspoint.com/microwave_engineering/index.htm

DIGITAL SIGNAL AND IMAGE PROCESSING

ECE21RXXXX	Digital Signal and Image Processing	L	T	P	X	C
		3	0	2	0	4
Pre-requisite	**:**	Signals and Systems / Equivalent				
Course Category	**:**	Programme Core				
Course Type	**:**	Integrated Course				

Course Description:

This course aims to provide students with a detail knowledge on design of linear and nonlinear filters for 1D and 2D signals; Understand Finite word length effect; Understand the concepts of various image processing concepts in real time applications

Course Objective:

The objectives of this course are:

- To study about the design of IIR and FIR filters
- To study about standard image processing algorithms, Understanding of image processing system development
- To study the extraction and detection of images

Course Outcomes:

At the end of the course, the student will be able to:

CO1 : Apply transforms on various dimensional signals
CO2 : Design the FIR digital filters based on the given specifications
CO3 : Design the IIR digital filters based on the given specifications
CO4 : Design frequency domain filters and spatial filters for image enhancement
CO5 : Analyse the methodologies for image compression
CO6 : Understand the basic concepts of Digital Signal Processors.
CO7 : Communicate the technical information related to designed and conducted experiments by means of group presentations and written reports

Mapping of Course Outcomes:

CO /	PO												PSO		
PO	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M			M							L	L	M	
CO2	H	H		M	M		L					M	L	M	L
CO3	H	H		M	M		L					M	L	M	
CO4		H	L		L		M					H	L	M	L
CO5			M	M	M	L						M	L	M	L
CO6	M					L	L		L			L		L	L
CO7								H	H	H					H

Course Topics:

Unit 1: 1D, 2D Transforms

Signals (1D, 2D, 3D, Multidimensions), 1-D DFT, General Orthonormal Transform, 2-D DFT, 1-D DCT, 2-D DCT, Discrete Sine Transform, Hadamard Transform, KL Transform, Wavelet Transform

Unit 2: FIR Filters

Concept of FIR/IIR – Design Linear Phase FIR filter – Fourier Series Method, LPF Design of FIR Digital filters: Window method - Rectangular, Hamming, Hanning and Blackman window, Frequency sampling method.

Unit 3: IIR Filters

Digital design using impulse invariant and bilinear transformation Warping, pre-warping. Discrete time IIR filter from analog filter-Butterworth and Chebyshev Filter, Filter design (LPF, HPF, BPF, BRF) using frequency translation.

Unit 4: Image Enhancement and Image Interpolation

Image Enhancement: Grayscale Transformation, Contrast Stretching, Gamma Correction, Histogram Equalization, Unsharp Masking, Image Interpolation: Linear Interpolation, Polynomial interpolation. Edge Detection: Definition of an Edge-Finite Differences, Roberts Edge Detector, Sobel and Prewitt Edge Detectors, Marr-Hildreth Edge Detection, Canny Edge Detector.

Unit 5: Pixel Coding and DSP Processor

Huffman Coding, LZW Coding, DPCM of Image - JPEC: Standard, Case Study on Vehicle license plate character recognition and Water marking. Introduction to DS Processors — Architecture — Features — Addressing Formats — Functional modes.

Laboratory Experiments:

1 Representation of Magnitude and Phase spectrum using 2D-DFT by using MATLAB / equivalent software.
2 Representation of Magnitude and Phase spectrum using 2D-DCT and DST by using MATLAB / equivalent software.
3 Analysis of 2D signals like an Image using DWT by using MATLAB / equivalent software.
4 Design and implement of Basic filters using MATLAB / equivalent software
5 Design and implement of FIR filter using Rectangular and Hamming window for the given specifications using MATLAB / equivalent software
6 Design and implement of FIR filter using Frequency sampling method for the given specifications using MATLAB / equivalent software
7 Design and implement of IIR filter using bilinear transformation, and impulse invariant transformation by using MATLAB / equivalent software.
8 Design and implementation of filter using Butterworth filter and Chebyshev filter
9 Design of various filters with frequency transformation technique using MATLAB
10 Poor contrast image enhancement using Histogram Equalization
11 Edge Detection using Sobel and Prewitt operators for the given image
12 Detection of edges using Canny edge detection method

13 Watermarking creation and extraction.

Textbooks:

1. John G Proakis, Dimtris G Manolakis, “Digital Signal Processing Principles, Algorithms and Application”, Pearson, Fifth Edition, 2016.
2. Rafael C., Gonzalez, and Richard E. Woods, “Digital Image Processing”, Pearson, Fourth Edition, 2017.
3. Sen-Maw Kuo, Woon-Seng Gan, “Digital Signal Processors, Architecture, Implementations and Applications”, Pearson, Second Edition, 2016.
4. https://nptel.ac.in/courses/117/102/117102060/

References:

1. Lawrence R. Rabiner and Bernard Gold, “Theory and Applications of Digital Signal Processing”, Pearson, Second Edition, 2016.
2. William K. Pratt, “Digital Image Processing”, Wiley, Fourth Edition, 2016.
3. Massimo Tistarelli, Christophe Champod, “Handbook of Biometrics for Forensic Science”, Springer, 2017.
4. Sanjit Mitra, “Digital Signal Processing– A Computer Based approach”, McGraw Hill, Fourth Edition, 2013.
5. Vinay K. Ingale, John. G. Proakis, Asoke K. Gosh, “Digital Signal Processing using Matlab”, PHI, Third Edition, 2015.
6. John W. Leis, “Digital signal processing using MATLAB for Students and researchers”, Wiley, Third Edition 2011.
7. https://nptel.ac.in/courses/117/105/117105135/

PROGRAM ELECTIVES

IC CAD - DESIGN AUTOMATION

IC CAD - Design Automation	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: Basic C programming language / Equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

To learn the basics and advance of Linux, Shell Scripting, Tcl and Perl Scripting to automate the task to perform the automation job in the core electronics field and enhance the productivity to become a successful Electronic Engineer.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Explain the architecture of Linux OS and CLI navigation to perform various linux commands.

CO2: Describe Shell, Shell types and Shell scripting language.

CO3: Apply Tcl data structure and Tcl String Subcommands in programming for automation.

CO4: Apply Perl Variables, numerical operators, and control statements in Perl script for automation.

CO5: Apply functions, regular expression, and string substitutions in scripts for automation.

CO6: Perform the lab based on the Linux module, Shell scripting, Tcl and Perl scripting and document the same.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	H	M	M	M							L	H	M	L
CO2	H	M	H	H	M			M				L	H	M	L
CO3	M	H	H	M	M			M				L	H	M	L
CO4	M	H	H	H	M			M				L	H	M	L
CO5	M	H	H	H	M			M				M	H	M	M
CO6	H	H	H	H	M	L	L	M	H	H	H	M	H	M	M

Course Topics:

Unit 1: Linux OS Basics

Introduction to linux, Unix Architecture – CLI navigation, reading files using CLI, managing files and directories – Finding difference between files, Redirection I/O command,

Handling large files, File permissions – Searching for file and directories and finding file types –User management, archiving compression –Scheduling jobs, finding disk space, Finding memory usage, foreground/background jobs.

Unit 2: Shell Scripting, SED and AWK Commands

Introduction to Shell – Introduction to Vim text editor, Shell types, Introduction to Shell scripting – Shell parameters, shell variables, shell script execution, Debugging shell scripts –

Application based shell script example – Introduction to SED, SED syntax, loops, Branches – Pattern buffer and range, sed commands, handling special character and string – Introduction to AWK, syntax and example, AWK variables and operators – Regular expressions, Arrays, if/else statement in AWK, Loops, Built in Functions in AWK, Output redirection and Printing in AWK.

Unit 3: Tcl Scripting

Introduction to Tcl , Running Tcl, simple text output, Variable declaration –Evaluation and substitution, Numeric and textual comparison – Loop commands–Adding new command to Tcl-proc, Variation in proc arguments and return values–Variable scope-global and upvar–Tcl data structure, Adding and deleting members in list–More list commands - lsearch, lsort, lrange–String Subcommands - length index range–String comparisons: compare match first last wordend–Modifying Strings - tolower, toupper, trim, format

Unit 4: Perl Programming - Basics

Introduction to Perl,– Application of Perl, Perl program execution and Debugging Perl script, Writing better, cleaner code in Perl, Variable and Data types – Scalar Interpolation, Getting input from keyboard, Removing \n and \b from a string using chomp and chop –Comparison Operator, Perl Variables: Scalar Variable, String arithmetic, Logical Operators: &&, || – Loop Control statements, $_:Special variable Syntax – Perl Variables: Array Variable, Length of an Array, Special Array: @ARGV

Unit 5: Perl Programming: Arrays, Functions, Regular Expressions, String Substitution

Associative Arrays or Hashes, Keys in a Hash – Subroutine Definition and Function Call – Useful Perl Functions and Variable Syntax – Opening and closing a file, Printing to a file, Reading from a file – Regular expressions, interesting string processing, Greedy vs. Non-greedy matching – String Substitution – global substitution, substr, index and rindex.

Experiments:

Linux OS based commands, Shell Scripting, Tcl and Perl Scripting based lab implementation on Linux Terminal Interface.

1. Linux Commands
    - 1.1 Enter the commands at the UNIX prompt and try to interpret the Output.
    - 1.2. List the files within the directory recursively.
    - 1.3. Use the commands cd, ls and pwd to explore the file system.
    - 1.4. Create a parent directory structure using relative path and absolute path navigation.
2. Linux Commands (Files)
    - 2.1. Create an empty file called hello.txt without using touch command and add content into it.
    - 2.2. Append the new line into the file hello.txt without opening it.
    - 2.3. Create a file and add month wise calendar names into it.
        - (a) Print only June and July on terminal screen using head command
        - (b) Print only March and April on terminal screen using tail command
    - 2.4. Create two files and add content into it and do comparison using diff command.
3. Linux Advanced Commands
    - 3.1. Work on setting/revoking permission-based exercise.

3.2. Create a file called calender.txt and add month wise calendar name randomly into it. Print on terminal screen as per calendar wise month order

3.3. Create a file called f1.txt and add content till next 20 lines into it. Split this information into three files.

3.4. Create a file called pattern.txt and fill this file with given contents.

"Good morning to all Participants"

"Welcome to the Linux OS World"

"Let's learn about the grep command".

Use a grep command and highlight "Linux" on terminal screen with using different grep options.

3.5. Give a live execution demo to differentiate file and find commands.

3.6. Create a file called f1.txt and add content till next 15 lines into it. Print line number 5 to line number 8 only on the terminal screen?

4. Shell Scripts

4.1. Write a script "welcome_shell.sh" inside to your home directory and follow the below task:

(a) Create a new directory name as "shell_work" and it's subdirectory as "assignment"

(b) List out all files and folder located at home directory and redirect an output to ls.log

(c) Move ls.log file inside to "assignment" directory

4.2. Write a script for the following tasks:

(a) Print a message "Hello Students! Welcome to Shell Scripting World!"

(b) Print the current time, date, and year on terminal screen.

(c) Move "welcome_shell.sh" script to the current working directory "assignment" and print message "welcome_shell.sh file moved successfully!"

5. Shell Scripts

5.1. Write a shell script to find whether an input integer is even or odd.

5.2. Write a shell script that asks for the capital of India and repeats the question until the user gets it right. Enter capital in small letters.

5.3. The marks obtained by a student in two different subjects are input through the keyboard. The student gets a grade as per the rules. (Using elif clause).

6. Shell Scripts

6.1. Write a shell script to find out whether a file is writable or not. File name must be input by the user through command-line.

6.2. Write a program in UNIX to accept a year and months in that year and display calendar of those months.

6.3. Write a shell script to find whether an input year is leap year or not.

6.4. Write a menu driven program which has following option-

(a) Show Today's date/time (b) Show files in current directory (c) Show calendar (d) Start editor to write letters (e) Exit/Stop

7. Shell Scripts

7.1. Write a script to calculate the factorial of a given number.

7.2. Write a script to accept a number from standard input and determine whether it is odd or even number.

8. Script

8.1. Write a script to find number of lines, size and permission given to a file.

8.2. Write a script append 2 lines at the start and end of a file.

9. Script for IC Design Automation

9.1. Create an updated version of the given spice netlist which has width of all the transistors doubled (ref_files/spice netlist diff1.pex.spi)

9.2. Write a script to get wns (worst negative slack/Critical Path Slack), tns (total negative slack), number of violations for setup and hold in each timing report (use timing report ref_files/qor.txt)

9.3. Write a script to get start pin, stop pin, launch clock, capture clock, required time, arrival time and slack for each timing path (use timing report ref_files/timing_report.txt)

10. Perl Script

10.1. Write a program for following tasks.

(a) Concatenate five different strings say “Welcome”, “to”, “Perl”, “Scripting”, “Session”

(b) Print “Perl” three times using a single print function.

(c) Pass two arguments from terminal say, “Good Morning” and “Have a Nice Day”

10.2. Write a program to perform simple arithmetic operation.

(a) Addition (c) Multiplication (e) Exponent (b) Subtraction (d) Division

10.3. Write a program to convert a scalar variable into an array variable.

10.4. Write a program to calculate the size of a string assigned to scalar variable.

11. Perl Script

11.1. Write a program to list out four different ways to declare the array variable having value assigned as “Welcome to Perl Scripting Session” and print all index on new line terminal using “$_” special variable syntax.

11.2. Write a program to check and print the last index of an array variable.

11.3. Write a program to pass arguments from the terminal screen for the following condition.

(a) If an argument matches with “Perl”, then message shall be printed as “Welcome to Perl Scripting Session”

(b) If an argument matches with “Shell”, then message shall be printed as “Welcome to Shell Scripting Session”

(c) If an argument matches with “Tcl”, then message shall be printed as “Welcome to Tcl Scripting Session”

(d) If an argument doesn't match with any of the above-mentioned condition, then message shall be printed as “Welcome to Automation World!”

11.4. Write a for loop program to print the message “Welcome Students!” 5 Times using (a) C Programming Syntax like initialization, condition and incremental (b) “$_” Special Variable Syntax

11.5. Write a nested if-else loop program for the following conditions (a) If condition is equal to “Backend”, it shall execute the 2 nd if-else block as below.

(i) If condition is PD, it shall execute if block with message “Welcome to Physical Design Domain!”

(ii) If condition is not PD, it shall print else block with message “Welcome to Full Custom Design Domain!”

(b) If the condition is not equal to “Backend”, it shall print “Welcome to RTL Verification Domain!”

12. Scripting Program

12.1. Write a program to pass argument from terminal say “Perl Session” using following loop (a) unless (b) until (c) do-while (d) do-until

12.2. Write a program for passing and removing index from array variable for month calendar using the function (a) push (b) pop (c) unshift (d) shift.

12.3. Write a program to print number of days associated to calendar months respectively in a tabular format.

12.4. Write a subroutine program for the following arithmetic operation (a) Addition (b) Multiplication (b) Subtraction (c) Division

12.5. Write program with the use of regular expression/pattern matching syntax for Message:” Hello Students! Good morning” (a) Replace “Hello” With “Welcome” and print it.

Textbook(s):

1. Daniel P. Bovet, Marco Cesati, “Understanding the Linux Kernel”, O'Reilly, 2005.
2. Brent B Welch, Ken Jones with Jeffrey Hobbs, “Practical Programming in Tcl and Tk” Pearson / Prentice Hall, 2006.
3. Tom Phoenix, Randal Schwartz, and Brian Foy, “Learning Perl”, O’Reilly, 5th Edition, 2011.

Reference(s):

1. Maurice J. Bach, “The Design of the UNIX Operating System”, Prentice Hall, 1996.
2. Mark Harrison, Michael McLennan, “Effective Tcl/TK Programming: Writing Better Programs with TCL and TK”, Addison-Wesley, 1998.
3. Tom Christiansen, Jon Orwant, and Larry Wall, “Programming Perl”, O’Reilly, 2012 (Fourth Edition).
4. Curtis Poe, “Beginning Perl”, Wiley, 2012.
5. Chromatic, Shane Warden, “Modern Perl”, Onyx Neon Press, 2015.

VERILOG HDL PROGRAMMING

Verilog HDL Programming	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: Digital Circuits and Systems Design / equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

To expose the students to the fundamentals of Verilog Language; To understand the design and verification of digital logic circuits using hardware description language i.e., Verilog.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Describe ASIC flow.

CO2: Analyse the basics of Hardware Description Languages, Program structure and basic language elements of Verilog.

CO3: Analyse types of modelling, modules, functions of Verilog and simulate related Programs.

CO4: Design and Simulate various Verilog descriptions for Combinational circuits and Sequential circuits.

CO5: Design of Mealy and Moore state models using Verilog HDL.

CO6: Adhere to standard HDL coding guidelines for digital design using Verilog.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H					L	L	M				M	M		L
CO2	M	H	H	H	H	L	L	M	L			M	M	H	L
CO3	M	H	H	M	H			M	L			M	M	H	L
CO4		H	H	M	H	L	L	M	M			M	M	H	L
CO5	M	M	H	M	H	M	M	M	M	L		M	M	H	L
CO6		H	H	M	H	L	L	M	M	M	L	M	L	H	L

Course Topics:

Unit 1: ASIC Flow and Verilog - Basics

What is ASIC Flow - Specification, architecture, microarchitecture - RTL Design- RTL Verification - Logical synthesis - DFT and LEC - static timing analysis- automatic place and route - parasitic extraction - physical verification. Introduction to HDL- Importance of HDL- Program structure for design and testbench.

Unit 2: Verilog Constructs: Data types, Operators, Levels of Abstraction

Datatypes and Operators: Types of Operators, Operator precedence - Levels of abstraction: Switch Level modelling, Gate and structural modelling, Dataflow modelling,

Unit 3: Verilog Constructs: Control Statements, Loops and Blocking, Non-blocking Assignments

Behavioural modelling - Continuous and Procedural assignments/blocks-always and initial-Control Statements and Loops: If....else statement, case statement, for loop, while, forever, repeat - Blocking and non-blocking assignments,

Unit 4: Verilog Constructs: Event Queue and Timing Controls

Synchronous and asynchronous circuits - Self Checking testbench for combinational and sequential circuits - Stratified event queue: Active events, inactive events, non-blocking events, monitor events - Timing controls: Events and timescale. Delays: Inertial and transport.

Unit 5: Verilog Constructs: Tasks and Functions

Task and Functions: task declaration, task call, function declaration, return value, function call, Function Rules - FSM: Moore and mealy model with overlap and nonoverlap - Coding guidelines and design planning.

Experiments:

1. Switch-level modelling -AND, OR, NAND, NOR, XOR, XNOR
2. Gate-level Modelling-Basic gates, MUX, Demux, Decoder, Encoder
3. Structural Modelling -Combinational circuits-MUX, Demux, Decoder, Encoder
4. Structural Modelling -Combinational Circuits-Adders, subtractors
5. Dataflow Modelling-Combinational Circuits -MUX, Demux, Decoder, Encoder
6. Dataflow Modelling-Combinational circuits -Adders, subtractors, comparators
7. Behavioural Modelling-Combinational circuits
8. Behavioural Modelling-Sequential circuits-Flipflops
9. Behavioural Modelling-Sequential circuits- Counters
10. Behavioural Modelling-Sequential circuits- shift registers
11. FSM- Moore model
12. FSM- Mealy model

Textbook:

1. Douglas J Smith, “HDL Chip Design: A Practical Guide for Designing, Synthesizing and Simulating ASICs and FPGAs Using VHDL or Verilog”, Doone Publications, ISBN: 978-0965193436.

Reference(s):

1. J Bhasker, “A Verilog HDL Primer”, Star Galaxy Publishing, 2005 Third Edition, ISBN: 978-0965039161.
2. Samir Palnitkar, “Verilog HDL: A Guide to Digital Design and Synthesis”, Prentice Hall, Second Edition, ISBN: 978-0132599702.

SYSTEM VERILOG FOR RTL VERIFICATION

System Verilog for RTL Verification	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: Verilog HDL Programming / equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

To learn the System Verilog constructs and apply constructs to model System Verilog testbench architecture.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Describe RTL verification and its need.

CO2: Understand different System Verilog constructs to build verification environment.

CO3: Use SystemVerilog specific constructs, randomization, and OOP concepts to run test cases/regressions, for efficient functional and code coverage.

CO4: Perform functional simulations to validate and debug designs using an industry standard RTL simulator.

CO5: Develop the SystemVerilog testbench architecture for a given RTL design.

CO6: Develop a complete and comprehensive verification plan for the given design specifications of a digital design.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H					M		M				M			L
CO2	H	M		M	H			M	L			M	M	H	L
CO3	H	M		M	H			M	L			M	M	H	L
CO4	H			M	H			M	L			L	M	M	L
CO5		M	H	M	H		L	M	H		L	M	H	H	L
CO6		M	H	M	H	L	L	M	H	H	L	M	H	H	H

Course Topics:

Unit 1: Fundamentals of System Verilog

Importance of System Verilog– Limitations of Verilog– Features of System Verilog– Datatypes – Arrays-Array manipulation methods.

Unit 2: System Verilog Constructs

Stratified event queue–Procedural constructs: combinational, latched, sequential logic – Loops– Functions, tasks –Parallel blocks: fork_join, fork_join_any, fork_join_none.

Unit 3: System Verilog Constructs – OOPs concepts

OOP's concepts: Handle and object creation, Parameterized class, Typedef class, Handle assignment, Shallow and deep copy, Static properties and Static methods, Inheritance and super keyword, Encapsulation, Polymorphism, Casting.

Unit 4: Advanced System Verilog Constructs

Interface- Modport- Virtual interface- Clocking block- Program Block-Randomization: Randomization and Disable, Randomization methods, Constraint block and disable constraints, Inclass and Extern constraints, Inside and inverted inside constraints, Weighted distribution, Implication operator and if-else constraints, Foreach constraints and functions, Inline constraints, Unique and bidirectional constraints- Events- Mailboxes- Semaphore

Unit 5: Modelling System Verilog Testbench Blocks and Coverage

Code coverage – Functional coverage – System Verilog architecture: Explanation of different blocks of architecture.

Experiments:

1. Example program for Datatypes -Enumerated type
2. Program implementing Arrays- array manipulation
3. Program demonstrating Loops, break statements
4. Implementation of Functions and tasks
5. Implementation of Interface
6. Implementation of Classes-inheritance
7. Classes-encapsulation example program
8. Classes-polymorphism example program
9. Randomization example program 1
10. Randomization example program 2
11. Modelling SV testbench for DUT - environment,testcases,transaction, driver
12. Modelling sv testbench for DUT- reference model,monitor,scoreboard,coverage

Textbooks:

1. Chris Spear and Greg Tumbush, "SystemVerilog for Verification: A Guide to Learning the Testbench Language Features", Springer Publications, 3rd Edition 2012. ISBN-10:1461407141 ISBN-13:978-1461407140

References:

1. "SystemVerilog: Unified Hardware Design, Specification, and Verification Language"–The IEEE 1800-2012 LRM3.
2. Ashok B. Mehta, "System Verilog Assertions and Functional Coverage", Springer, 2019.
3. Janick Bergeron, "Writing Testbenches Using SystemVerilog", Springer 2006.

ADVANCED SV CONSTRUCTS AND VERIFICATION USING PYTHON

Advanced SV Constructs and Verification using Python	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: System Verilog for RTL Verification / equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

To learn advanced System Verilog concepts i.e., assertions. To understand application of python in RTL design and verification.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the importance of the assertion-based verification methodology.
CO2: Distinguish between the different kinds of assertions used in monitoring designs.
CO3: Write assertions for some behavioural functionality described.
CO4: Apply python in RTL design
CO5: Apply python in RTL verification
CO6: Communicate the technical information related to application of python and assertions by means of oral and written reports.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H							L				M	M		L
CO2	H					L		L				M	M		L
CO3	L	M	M	L	M			M				M	M	M	M
CO4	L	H	H	M	H	M	L	M	M			M	M	H	M
CO5	L	H	H	M	H	M	L	M	M	L	L	M	M	H	M
CO6		H	H	M	H			M	H	M		M	M	H	L

Course Topics:

Unit 1: SV Assertions Fundamentals

Meaning of SystemVerilog Assertions - Importance of SystemVerilog Assertions - SystemVerilog Scheduling - Types of Assertions: Concurrent assertions, Immediate assertions - Building blocks of SVA - A simple sequence - Sequence with edge definitions - Sequence with logical relationship - Sequence expressions - Sequence with timing relationship - Clock definitions in SVA - Forbidding a property - A simple action block - Timing windows in SVA: Overlapping timing window - Indefinite timing window - Operators in SVA : Implication operator: Overlapped implication, Non-overlapped implication

Unit 2: Assertions Constructs: Basics

Implication with a fixed delay on the consequent, Implication with a sequence as an antecedent -Repetition operators: Consecutive repetition operator [*], Consecutive repetition operator [*] on a sequence, Consecutive repetition operator [*] on a sequence with a delay window, Consecutive repetition operator [*] and eventuality operator, Go to repetition operator [->],

Non-consecutive repetition operator [=], The “ended” construct, “$past” construct , “and” construct, “or” construct, “firstmatch” construct, “throughout” construct, “within” construct, “disable iff” construct

Unit 3: Assertions Constructs: Advanced Topics

The “intersect” construct, “matched” construct, “expect” construct, using if/else with implication-Built-in system functions, Multiple clock definitions in SVA, Connecting SVA to the design, SVA for functional coverage, APB explanation, assertions applied to APB protocol.

Unit 4: RTL Design in Python

Introduction to MyHDL- Goal of MyHDL - Basic MyHDL simulation, decorators, generators- MyHDL constructs - Signals and concurrency, Parameters, ports and hierarchy - Hardware-oriented types - The intbv class, Bit indexing, Bit slicing, The modbv class , Unsigned and signed representation - Structural modelling : Introduction, Conditional instantiation, Converting between lists of signals and bit vectors , Inferring the list of instances- RTL modelling: Introduction, Combinatorial logic, Sequential logic, FSM - High level modelling- :bus functional procedures, memory with built in types

Unit 5: RTL Verification in Python

Testbench, simulation, waveform tracing for combinational circuit- Testbench, simulation, waveform tracing for sequential circuit- Conversion to Verilog: Introduction, Conversion of lists of signals, Conversion of Interfaces, Assignment issues, conversion of testbench - Conversion to Verilog examples: Combinatorial logic with tool demo, Sequential logic with tool demo- UART explanation- How to design and verify UART.

Experiments:

1. Implementation of Implication operator-overlapped
2. Implementation of Implication operator-non overlapped
3. Implementation of Repetition operator
4. Implementation of go to repetition operator
5. Implementation of SVA constructs
6. Implementation of built-in functions
7. Implementation of basic gates using MyHDL
8. Implementation of comparator using MyHDL
9. Implementation of counter using MyHDL
10. Implementation of flipflop using MyHDL
11. Implementation of FSM - Sequence detector using MyHDL
12. Implementation of memory using MyHDL

Reference(s):

1. Srikanth Vijayaraghavan and Meyyappan Ramanathan, “A Practical Guide for System Verilog Assertions”, Springer, 2014.

Reference(s):

1. Jan Decaluwe, “MyHDL manual”, Release 0.11, April 10,2020
2. Meher Krishna Patel, “FPGA designs with MyHDL”, 2018

UNIVERSAL VERIFICATION METHODOLOGY

Universal Verification Methodology	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: System Verilog for RTL Verification / equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Describe UVM verification methodology and its requirement.

CO2: Understand different UVM constructs to build verification environment.

CO3: Use UVM specific constructs, and SV OOP concepts to run test cases/regressions, for efficient functional and code coverage**.**

CO4: Perform functional simulations to validate and debug designs using an industry standard RTL simulator.

CO5: Model and develop the UVM testbench architecture for a given RTL design.

CO6: Develop a complete and comprehensive verification plan for the given design specifications of a digital design.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H					M		M				M	L		L
CO2	H	M		M	H			M	L			M	M	H	L
CO3	H	M		M	H			M	L			M	M	H	L
CO4	H			M	H			M	L			L	M	M	L
CO5		M	H	M	H		L	M	H		L	M	M	H	L
CO6		M	H	M	H	L	L	M	H	H	L	M	M	H	M

Course Topics:

Unit 1: UVM and its Constructs: Basics

Importance of UVM- Features of UVM– UVM component hierarchy tree– Phases – Factory - Developing UVM testbench architecture: top, test, environment, agent.

Unit 2: UVM and its Constructs: Sequence

UVM_sequence: `uvm_do and `uvm_do_with macro, `uvm_create and `uvm_send macro, `uvm_rand_send and `uvm_rand_send_with macro - UVM_sequence_item: UVM utility/field macros, Create and copy method, Compare and print method, Clone, and pack/unpack method - UVM config_db, UVM reporting.

Unit 3: UVM and its Constructs: Testbench Architecture

Developing UVM testbench architecture: driver, monitor, scoreboard – UVM communication: get, put topology, TLM FIFO, analysis ports.

Unit 4: Advanced UVM Constructs

Events – Callbacks: testbench with and without callbacks, callback class and macros, callback add method.

Unit 5: Modelling UVM Testbench Blocks and UVM RAL

Register model – Register environment – UVM architecture: Explanation of different blocks of architecture.

Experiments:

1. Implementation of different phases of UVM
2. Implementation of UVM phases in hierarchy of components
3. Implementation of factory in UVM- type override
4. Implementation of factory in UVM- instance override
5. Implementation of UVM Sequence_item methods: copy, print and compare
6. Implementation of different UVM Sequence macros
7. Implementation of UVM config_db to pass Interface and set variable value
8. Implementation of UVM reporting: severity, verbosity
9. Implementation of UVM TLM get topology
10. Implementation of UVM TLM FIFO
11. Modelling UVM testbench for DUT APB- environment, testcases, transaction, driver
12. Modelling UVM testbench for DUT APB- reference model, monitor, scoreboard, coverage

Textbooks:

1. Ray Salemi, “The UVM Primer: A Step-by-Step Introduction to the Universal Verification Methodology”, Boston Light Press, 2013, ISBN-13:978-09741649392.

References:

1. Kathleen A. Meade, Sharon Rosenberg, “A Practical Guide to Adopting the Universal Verification Methodology (UVM)”, Cadence Design Systems, 2010 (Second Edition)
2. Benjamin Ting, “UVM Testbench Workbook”, Lulu Press, 2017,
2. www.chipverify.com
3. www.verificationguide.com

SYSTEM VERILOG FOR VERIFICATION AND ASSERTION

System Verilog for Verification and Assertion	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: System Verilog for RTL Verification / equivalent
Course Category: Program Elective
Course Type: Integrated Course

Course Objective(s):

The objective of this course is to provide students with

1. Insight to apply System Verilog concepts to do synthesis, analysis, and architecture design.
2. Understanding of SystemVerilog and SVA for verification and understand the improvements in verification efficiency.
3. Understand advanced verification features, such as the practical use of classes, randomization, checking, and coverage.
4. Knowledge to communicate the purpose and results of a design experiment in written and oral presentations

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the importance of the assertion-based verification methodology.
CO2: Distinguish between the different kinds of assertions used in monitoring designs.
CO3: Write assertions for some behavioural functionality described.
CO4: Describe the role of Assertions in the verification process.
CO5: Explain the randomisation as applied in IC verification.
CO6: Communicate the technical information related to assertions by means of oral and written reports.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H							L				M	M		L
CO2	H					L		L				M	M		L
CO3	L	M	M					M				M	M	M	M
CO4	L	H	H			M	L	M	M			M	M	H	M
CO5	L	H	H			M	L	M	M	L	L	M	M	H	M
CO6		H	H	M	H			M	H	M		M	M	H	L

Course Topics:

Unit 1: Verification Guidelines

Verification Process, Basic Test bench functionality, directed testing, Methodology basics, Constrained-Random stimulus, Functional coverage, Test bench components, Layered test bench, Building layered test bench, Simulation environment phases, Maximum code reuse, Test bench performance.

Unit 2: Data Types

Built-in data types, Fixed-size arrays, Dynamic arrays, Queues, Associative arrays, linked lists, array methods, choosing a storage type, creating new types with type def, Creating user-defined structures, Type conversion, Enumerated types, Constants strings, Expression width.

Unit 3: Procedural Statements and Routines

Procedural statements, tasks, functions and void functions, Routine arguments, returning from a routine, Local data storage, Time values Connecting the test bench and design: Separating the test bench and design, Interface constructs, Stimulus timing, Interface driving and sampling, Connecting it all together, Top-level scope Program – Module interactions

Unit 4: System Verilog Assertions

Basic OOP: Introduction, think of nouns, not verbs, your first class, where to define a class, OOP terminology, creating new objects, Object de-allocation, using objects, Static variables vs. Global variables, Class methods, defining methods outside of the class, scoping rules, using one class inside another, understanding dynamic objects, copying objects, Public vs. Local, straying off course building a test bench.

Unit 5: Randomization

Introduction, what to randomize, Randomization in System Verilog, Constraint details solution probabilities, controlling multiple constraint blocks, Valid constraints, In-line constraints, The pre randomize and post randomize functions. Random number functions, Constraints tips and techniques, Common randomization Problems, Iterative and array constraints, atomic stimulus generation vs. Scenario generation, Random control, Random number generators, Random device configuration.

Experiments:

1. Implementation of Sparse memory
2. Implementation of Semaphore
3. Implementation of Mailbox
4. Example program for Classes
5. Example program for Polymorphism
6. Developing a program to understand Coverage
7. Implementation of Assertions
8. Implementation of Implication operator-overlapped
9. Implementation of Implication operator-non overlapped
10. Implementation of Repetition operator
11. Implementation of go to repetition operator
12. Implementation of SVA constructs
13. Implementation of built-in functions

Textbook(s):

1. Srikanth Vijayaraghavan and Meyyappan Ramanathan, “A Practical Guide for System Verilog Assertions”, Springer, 2014.

Reference(s):

1. Chris Spears, “System Verilog for Verification”, Springer, 2nd Edition
2. M. Bushnell and V. D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers

3. IEEE 1800-2009 standard (IEEE Standard for SystemVerilog— Unified Hardware Design, Specification, and Verification Language).

OBJECT ORIENTED PROGRAMMING AND DATA STRUCTURES USING PYTHON

Object Oriented Programming and Data Structures using Python	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: Basic Programming / equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

To develop problem solving skills. To learn programming and to solve problems using Python.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Define the introduction to OOPS concept with respect to Python.
CO2: Apply programs to implement various computational tasks which requires loops and conditional statements and OOPS concepts.
CO3: Write programs using Classes and inheritances.
CO4: Apply programs to implement the concept of Data Structure using Python.
CO5: Estimate the work as part of a team and implement various advanced Data Structures.
CO6: Design object-oriented programs to implement daily life problems and their solutions.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	L	L	L										H		
CO2	M	M	L	L			H						H	M	L
CO3	H	M	M	M	M		H						H	H	L
CO4	L	L	L	M	L		H						H	M	L
CO5	H	L	H	M	L	L		H	H		L		H	M	M
CO6	M	M	L	L				M	H	H		L	H	M	M

Course Topics:

Unit 1: OOPs Basics

Introduction to OOPS, Difference between structured and object-oriented programming, features of OOP, Classes and Objects, Access specifiers, member and non-member functions, this pointer, Use of References, Constructors and Destructors, const objects, static class members, constant data members, Encapsulation, Abstraction, Namespaces, dynamic memory management.

Unit 2: Polymorphism and Graphical User Interfaces

Polymorphism in Python, Instance and class data, Class level attributes, changing class attributes, Alternative constructors, customizing functionality, Graphical user interfaces; event-driven programming paradigm, Tkinter module, creating simple GUI, buttons, labels,

entry fields, dialogs, widget attributes - sizes, fonts, colours layouts, nested frames, Implementation of a Simple GUI Interface with Example.

Unit 3: Classes and Inheritance

Classes, Class instances, Methods, Multiple Inheritance, Multilevel, Inheritance, Hybrid Inheritance, Properties, Special Methods, Emulating built-in Types, overriding, Decorators, Iterators and Generators, Concept of generalization and specialization, abstract class, virtual functions, pure virtual functions.

Unit 4: Data Structures

Abstract Data Types, Introduction, Abstractions, Abstract Data Type, Data Structures, General Definitions, The Date Abstract Data Type, Defining the ADT, Using the ADT, Preconditions and Postconditions, Implementing the ADT, Bags, The Bag Abstract Data Type, Selecting a Data Structure, List-Based Implementation, Iterators, Designing an Iterator, Using Iterators, Application: Student Records, Designing a Solution, Searching and Sorting, Searching, The Linear Search, The Binary Search, Bubble Sort, Selection Sort, Insertion Sort, Working with Sorted Lists, Maintaining a Sorted List, Merging Sorted Lists, The Set ADT Revisited, A Sorted List Implementation, Linked Structures, Introduction, The Singly Linked List, Traversing the Nodes, Searching for a Node, Prepending Nodes, Removing Nodes, The Bag ADT Revisited, A Linked List Implementation, Comparing Implementations, Linked List Iterators, More Ways to Build a Linked List, Using a Tail Reference, The Sorted Linked List, The Sparse Matrix Revisited.

Unit 5: Stacks, Queues, Hash Tables

An Array of Linked Lists Implementation, Comparing the Implementations, Application: Polynomials, Stacks, The Stack ADT, Implementing the Stack, Using a Python List, Using a Linked List, Stack Applications, Balanced Delimiters, Evaluating Postfix Expressions, Application: Solving a Maze, Backtracking, Designing a Solution, The Maze ADT, Implementation, Queues, The Queue ADT, Implementing the Queue, Using a Python List, Using a Circular Array, Using a Linked List, Priority Queues, The Priority Queue ADT, Implementation: Unbounded Priority Queue, Implementation: Bounded Priority Queue, Application: Computer Simulations, Airline Ticket Counter, Implementation, Hash Tables, Introduction, Hashing, Linear Probing, Clustering, Rehashing, Efficiency Analysis, Separate Chaining, Hash Functions, The HashMap Abstract Data Type, Application: Histograms, The Histogram Abstract Data Type, The Colour Histogram.

Experiments:

1. Create a class called student with various attributes like name, roll no, fees
2. Create Class named Person. Define Object and Methods for adding, Modifying, and deleting objects.
3. Create a class named Employee, having an indented block of code defining properties name, designation, and age.
4. Write a simple Python class named Student and display its type. Also, display the __dict__ attribute keys and the value of the __module__ attribute of the student class

5. Write a Python program to create two empty classes, Student and Marks. Now create some instances and check whether they are instances of the said classes or not. Also, check whether the said classes are subclasses of the built-in object class or not
6. Create a Vehicle class with max_speed and mileage instance attributes. Create a Vehicle class without any variables and methods. Create a child class Bus that will inherit all the variables and methods of the Vehicle class.
7. Write a Python program to locate the left insertion point for a specified value in sorted order
8. Write a Python program to insert items into a list in sorted order.
9. Write a Python program to create a queue and display all the members and size of the queue.
10. Write a Python program to Create a Stack and Display all the elements and the size of the Stack.
11. Write a Python program to Create a linked list and display all the elements and the size of the linked List.
12. Write a Python program to create a FIFO and LIFO queue.

Textbook(s):

1. Allen Downey, Chris Meyer, Jeffrey Elkner., "How to think like a Computer Scientist: Learning with Python", Wiley, 2016 ISBN 0-9716775-0-6
2. Mark Lutz, "Learning Python: Powerful Object-Oriented Programming", O'Reilly Media 5th Edition, 2013 ISBN: 9781449355739

Reference(s):

1. Kenneth A. Lambert, B. L. Juneja, "Fundamentals of Python", Cengage Learning, 2015. ISBN: 9788131529034
2. S. A. Kulkarni, "Problem Solving and PYTHON Programming", Yes Dee Publishing Pvt Ltd, 2nd edition, 2018, ISBN: 978-9380381688
3. Mark Summerfield, "Programming in Python 3: A Complete Introduction to the Python Language", Pearson, 2nd Edition, 2018, ISBN: 978-0321680563
4. Yashvant Kanetkar, Aditya Kanetkar, "Let Us Python", BPB Publications, 1st Edition, 2019, ISBN: 978-9388511568
5. Allen Downey, "Learning with Python", Dreamtec Press, 1st Edition, 2015, ISBN: 978-9351198147
6. https://docs.python.org/3/reference/

EMBEDDED SYSTEMS FOR IOT

Embedded Systems for IoT	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: Digital Circuits and System Design / equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

To understand what Embedded Systems, their components, applications, are ARM based processor architecture, interfacing peripherals.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Demonstrate the understanding of concepts, applications in IOT, ARM7 Instruction set and Assembly program development.

CO2: Describer about peripherals, timers, and interrupt.

CO3: Develop programs for ARM7 LPC2148, 32-bit microcontroller to interface peripherals.

CO4: Summarise ARM based cortex M4 MCU Architecture and its development environment, peripheral interfacing.

CO5: Demonstrate the understanding of low power Requirements, and RTS support while interfacing peripherals with various functional blocks of MCU`

CO6: Apply the interfacing of peripherals and test the output on target/simulator in a laboratory as a team/individual work.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	L	M	M	H			M					H	H	L
CO2	M	L	M	M	H			M					H	H	L
CO3	M	L	M	M	H			M					H	H	L
CO4	M	L	M	M	H			M					H	H	L
CO5	M	L	M	M	H			M					H	H	L
CO6	M	L	M	H	H			M	H	H		H	H	H	M

Course Topics:

Unit 1: Embedded Systems and ARM Based Microcontroller Architecture - Basics

History and need of Embedded System, Basic components of Embedded System, hardware and Software, Challenges and design issues, Choice of the Microcontroller, Classification of Controller, Single core, Multi core, Introduction to ARM, Features, States, Modes, Comparison between various ARM versions, ARM7 Instruction Set, Implementation of code in Assembly.

Unit 2: ARM Microcontroller Architecture

ARM 5 stage Pipeline, Pipeline Hazards, Data forwarding - a hardware solution, ARM addressing modes, various language constructs, Bit operators, Basic Electronics, Sensors and Actuators

Unit 3: ARM Microcontroller and Peripherals Interfacing

Introduction to LPC2148, LPC 2148 Datasheet and schematics, ARM7 GPIO Usage of GPIO registers, Pin Configuration and PINSELECT Registers, Code review/code development and testing of various IO devices LED, Switch, Debugging/testing the code flow in Simulator/target board (LPC2148)

Unit 4: Advanced Peripherals Interfacing

Coprocessor, Cache Memory Mapping functions, MPU, MMU, AMBA Standards, Interfacing PWM, UART, RTC, WDT with ARM7 MCU

Unit 5: Cortex-M Microcontroller Architecture and Peripherals Interfacing

Difference between interrupts and exceptions, Various CORTEX-M Cores, Cortex M4 MCU architecture, Development Environment and tools, Interfacing peripherals, program development and testing on simulator/target board

Experiments:

1. Develop assembly program for
   a) Adding two register contents
   b) Subtracting two register contents
   c) Multiplication of two register contents
   Use any registers from r0-r6 as registers to store operands and r7 to r10 to store the result.
   Note: Implement the above code using only mov and arithmetic instructions
2. Develop assembly program for implementing the following:
   a) Store a value 1 to R1
   b) Add the value of R1 to R10 and store the result back to R10
   c) Then left shifting R1 by 1, add the shifted value to R10
   d) Then shift R1 by 2, then by 3 and then by 4, each time add the shifted value to R10
   e) Finally check what is the value of R10
   Note: Implement the above code using only mov, add and LSL instructions
3. Develop the program for implementing the following:
   a) Store a value 0xFF to R1
   b) Drop the first nibble using LSR and store the result in R10. What should be the value of R10?
   Note: Implement the above code using only mov and LSR instructions
4. Develop an assembly program for the following using Register indirect with offset.
   a) Store values 1,2,3,4,5 in registers from R1-R5
   b) Store the address 0x4000 0000 in R0
   c) Store the value in R1 to [R0]
   d) Store the value in R2 to [R0+4]
   e) Store the value in R3 to [R0+8]
   f) Store the value in R4 to [R0+12]
   g) Store the value in R5 to [R0+16]
   h) Load the value at [R0] to R8
   I) Load the value at [R0+4] to R9

j) Load the value at [R0+8] to R10
k) Load the value at [R0+12] to R11
l) Load the value at [R0+16] to R12
m) Store the sum of R8, R9, R10, R11, R12 to R13
Note: Implement the above code using only mov, add, single load str instructions

5. Develop an assembly program for the following using pre increment.
   a) Store values 1,2,3,4,5 in registers from R1-R5
   b) Store the address 0x4000 0000 in R0
   c) Store the value in R1 – R5 to [R0] – [R0+16] using pre increment
   d) Load the value at [R0] – [R0+16] into R7, R8, R9, R10, R11 using pre-increment
   e) Store the sum of R7, R8, R9, R10, R11 to R13
   Note: Implement the above code using only mov, add, single load, str instructions
6. Write a program to add the numbers from 1 to 15 using Branch instruction.
   Write an algorithm to implement nested sub routine call.
   a) main flow should call subroutine A, Subroutine A should call subroutine B, Subroutine B should return to subroutine A, Subroutine A returns to main flow.
   b) Implement the same in assembly.
   Implement Stack and Queue using Assembly instructions.
7. Write a program for the following:
   a. Toggling ALL the LEDs on the board
   b. use macro to identify the IO pin to be used.
   c. Try the above program with varying delays for ON time and OFF time.
8. Write a program to control the LED's using a switch.
9. Interface LCD with ARM7.
10. Interface PWM with ARM7.
11. Interface RTC and WDT with ARM7.
12. Write a program for driving Digital IO on MSP432.

Textbook(s):

1. Steve Furber, "Arm System-On-Chip Architecture" Pearson 2001 (2nd Edition)
2. Andrew N. Sloss, Dominic Symes, Chris Wright, "ARM System Developer's Guide Designing and Optimizing System Software". Elsevier, 2004

Reference(s):

1. ARM Compiler v5.06 for µVision ARMASM User Guide
2. ARM7TDMI Technical Reference Manual
3. Muhammad Ali Mazidi, Janice G. Mazidi, Rolin D. McKinlay, "The 8051 Microcontroller and Embedded Systems" Pearson, 2006 (Second Edition)
4. AMBA™ 3 APB Protocol v1.0 Specification
5. Microcontroller Engineering with MSP432 Fundamentals and Applications by Ying Bai (z-lib.org)

SYSTEM DESIGN AND APPLICATION FOR IOT

System Design and Application for IOT	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: Embedded Systems for IoT / equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

To understand Software Engineering for Embedded Systems and embedded systems applications in IOT Doman, Understanding of various serial protocols like I2C, SPI, UART, ARM based Microcontroller Architecture and peripheral interfacing

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Demonstrate understanding of Software Design for Embedded Systems
CO2: Apply interfacing of advanced peripherals with ARM7 and various serial protocols like I2C, SPI.
CO3: Apply peripheral interfacing with Cortex-M based controller.
CO4: Apply Cortex-M based SOC functional blocks and advanced peripheral interfacing.
CO5: Demonstrate understanding of I2C and SPI interfacing with cortex-M4 based controller.
CO6: Apply the interfacing of peripherals and test the output on target/simulator in a laboratory as a team/individual work.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	M	L	L	M	H			M					H	H	L
CO2	M	M	L	M	H			M					H	H	L
CO3	M	M	M	M	H			M					H	H	L
CO4	M	M	M	M	H			M					H	H	L
CO5	M	M	M	M	H			M					H	H	L
CO6	M	M	M	M	H			M	M	M		H	H	H	M

Course Topics:

Unit 1: Software Design

Software Engineering for Embedded Systems, OS concepts and GPOS Scheduling algorithms, RTOS concepts and Scheduling, ARM cortex M4 Instructions, Bit field processing instructions, Saturation instructions, Exception related instructions, Sleep mode instructions, Assembly programs

Unit 2: ARM7 Advanced Peripheral Interface

Interfacing ADC, DAC, UART, I2C, SPI using ARM7 processor.

Unit 3: Cortex-M Peripheral Interface

Introduction to MSP432 Datasheet and launch pad, schematics, ARM cortex M4 Development procedure, Peripheral driver library and API functions, GPIO Usage of GPIO registers, Pin Configuration and PINSELECT Registers, Code review/code development and testing of various IO devices LED, Switch, Debugging/testing the code flow in Simulator/target board launch pad), Cortex-M4 and RTOS, 16- and 32-bit timers, Interfacing RTC, WDT, ADC, DAC

Unit 4: Cortex-M Advanced Peripheral Interface

Low power management, Debug Support, MSP 432 MCU memory system: Memory architecture, SRAM, SRAM memory map, control and status registers Bit band operations, Internal ROM, Boot loader, Flash memory VFP, MSP432 FPU, Analog Comparator,

Unit 5: Cortex-M Advanced Peripheral Interface – Communication Protocols

I2C Interface, SPI Interface, UART Interface, Interfacing GSM, GPS, CAN Protocol, DSP

Experiments:

1. Write a program to Display the following message on the first line of the LCD "Embedded" and "Systems" on the second line
2. Develop a program to send and receive data using UART for ARM7.
3. Interface ADC with MCU, read ADC value and print it to LCD.
4. Write a program to read ADC value and print it to UART.
5. Write a program to input the values in the range of 1 – 1023 to DAC and print their corresponding analog output to UART.
6. Write a program to toggle the LEDs, use timers for delay generation.
7. Write a program to toggle the LEDs on interrupt generated on ext3.
8. Interface RTC and print time on UART
9. Write a program to generate PWM signals using PWM1 with 50% duty cycle and PWM2 with 70% duty cycle.
10. Write a program to interface WDT with varying amount of timeout values.
11. Write a program to write data to EEPROM, read from EEPROM and display on LCD.
12. Write a program to write data to EEPROM, read from EEPROM and display on UART.

Textbook(s):

1. Ying Bai, "Microcontroller Engineering with MSP432 Fundamentals and Applications", CRC Press, 2016.
2. Andrew N. Sloss, Dominic Symes, Chris Wright, "ARM System Developer's Guide Designing and Optimizing System Software". Elsevier, 2004

Reference(s):

1. Steve Furber, "Arm System-On-Chip Architecture" Pearson 2001 (2nd Edition)
2. ARM Compiler v5.06 for µVision ARM ASM User Guide
3. ARM7TDMI Technical Reference Manual
4. AMBA™ 3 APB Protocol v1.0 Specification
5. Cortex-M4 Technical Reference Manual
6. https://www.ti.com/lit/ds/symlink/msp432p401r.pdf

IoT PROTOCOLS AND THEIR APPLICATIONS

IoT Protocols and their Applications	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: System Design and Applications for IoT / equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

The purpose of this course is to impart knowledge on IoT Architecture and various protocols, study their implementations.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Summarize the Architectural Overview of IoT.
CO2: Demonstrate the IoT Reference Architecture and Real-World Design Constraints.
CO3: Apply various IoT Protocols (Datalink, Network, Transport, Session, Service).
CO4: Distinguish the various IoT Protocols of the Transport Layer and Session Layer.
CO5: Justify the Service Layer and Security in IoT.
CO6: Build the various protocols for IoT applications in a laboratory.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1		L	M	L		L	H	M			L	M	M	L	M
CO2		M	M	M		L					L	M	M	L	L
CO3		L	M	H	M	M		L				M	M	M	L
CO4		L	H	H	H	H	H	H			L	H	M	M	M
CO5		M	M	M		L					L	M	M	L	L
CO6		L	M	H	M	M		L				M	M	H	M

Course Topics:

Unit 1: IoT Overview

IoT-An Architectural Overview– Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations. M2M, IoT Technology Fundamentals- Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service (XaaS)

Unit 2: IoT Architecture

IoT Architecture-State of the Art – Introduction, State of the art, Reference Model and architecture, IoT reference Model, IoT Reference Architecture- Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views, Real-World Design Constraints- Introduction, Technical Design constraints-hardware, Data representation and visualization, Interaction and remote control, On RFID False Authentications: YA TRAP – Necessary and sufficient condition for false authentication prevention,

Unit 3: IoT Data Link Layer and Network Layer Protocols

PHY/MAC Layer (3GPP MTC, IEEE 802.11, IEEE 802.15), Wireless HART, ZWave, Bluetooth Low Energy, Zigbee Smart Energy, DASH7 - Network Layer-IPv4, IPv6, 6LoWPAN, 6TiSCH, ND, DHCP, ICMP, RPL, CORPL, CARP

Unit 4: Transport and Session Layer Protocols

Transport Layer TCP, MPTCP, UDP, DCCP, SCTP-TLS, DTLS, Session Layer HTTP, CoAP, XMPP, AMQP, MQTT, Toward Web Enhanced Building Automation Systems - heterogeneity between existing installations, native IP devices - loosely-coupled Web protocol stack –energy saving in smart building

Unit 5: Service Layer Protocols and Security

Service Layer -oneM2M, ETSI, M2M, OMA, BBF, Security in IoT Protocols – MAC 802.15.4, 6LoWPAN, RPL, Application Layer, Sustainability Data and Analytics in Cloud-Based M2M Systems, Social Networking Analysis - Building a useful understanding of a social network, leveraging social media and IoT to Bootstrap Smart Environments

Experiments:

1. Demonstration of the implementation of Wi-Fi protocol (IEEE802.11n) using Wi Fi Module on an Arduino Uno Board
2. Implement BLE 4.0 (Bluetooth Low Energy) Protocol
3. Write a program to implement the NFC protocol using NFC reader module
4. Write a program to the implementation IEEE 802.15.4 Protocol
5. Write a program for the implementation of Z-Wave protocol using RF module
6. Write a program for the implementation of LoRa protocol
7. Write a program on Arduino/Raspberry Pi to publish temperature data to MQTT broker
8. Write a program on Arduino/Raspberry Pi to subscribe to MQTT broker for temperature data and print it
9. Write program for the implementation of Internet of Things (IoT) with CoAP and HTTP Protocol
10. Write a program to create TCP server on Arduino/Raspberry Pi and respond with humidity data to TCP client when requested.
11. Write a program to create UDP server on Arduino/Raspberry Pi and respond with humidity data to UDP client when requested (A client-server application using UDP protocol).
12. Write a program for the implementation of 6LoWPAN Protocol

Textbooks:

1. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, “From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence”, 1st Edition, Academic Press, 2014. ISBN: 978-0124076846

Reference(s):

1. Peter Waher, “Learning Internet of Things”, PACKT publishing ISBN: 978-1783553532
2. Bernd Scholz-Reiter, Florian Michahelles, “Architecting the Internet of Things”, ISBN 978-3-642-19156-5 e-ISBN 978-3-642-19157-2, Springer
3. Daniel Minoli, “Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications”, ISBN: 978-1-118-47347-4, Wiley Publications
4. Vijay Madisetti and Arshdeep Bahga, “Internet of Things (A Hands-on-Approach)”, 1st Edition, VPT, 2014. ISBN: 978-0996025515
5. http://www.cse.wustl.edu/~jain/cse570-15/ftp/iot_prot/index.html

IOT SECURITY

IoT Security	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: IoT Protocols and their Applications / Equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

To impart the knowledge and technical skills in designing secured and trustable IoT systems.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Design and implement cryptography algorithms using C programs.
CO2: Solve network security problems in various networks.
CO3: Build security systems using elementary blocks.
CO4: Build Trustable cloud based IoT systems.
CO5: Solve IoT security problems using light weight cryptography.
CO6: Appreciate the need for cyber security laws and methods.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M											M		
CO2			M	M	H		H						L	H	L
CO3			L	H	H	L	H						L	H	L
CO4			L	M	H	L	H						L	H	L
CO5								H	H		L				M
CO6	H	M						M	H	H		L			M

Course Topics:

Unit 1: IoT Security Framework

IOT security framework, Security in hardware, Boot process, OS and Kernel, application, run time environment and containers, Need and methods of Edge Security, Network Security, Internet, Intranet, LAN, Security in Wireless Networks, Wireless cellular networks, Cellular Networks and VOIP, Security Requirements in IoT Architecture - Security in Enabling Technologies - Security Concerns in IoT Applications, Security Architecture on the Internet of Things

Unit 2: Elementary Blocks of IoT Security and Models Identity Management

Vulnerability of IoT and elementary blocks of IoT Security, Threat modelling – Key elements, Identity management Models and Identity management in IoT, Approaches using User-centric, Device-centric and Hybrid, Trust management lifecycle, Identity and Trust, Web of trust models, IoT IAM infrastructure – Authorization with Publish / Subscribe schemes, Access control,

Unit 3: Access Control in IoT, Light Weight and Cloud Cryptography

Capability-based access control schemes, Concepts, identity-based and identity-driven, Light weight cryptography, need and methods, IoT use cases, Cloud services and IoT – offerings

related to IoT from cloud service providers, Cloud IoT security controls – An enterprise IoT cloud security architecture, new directions in cloud enabled IoT computing, Cloud security,

Unit 4: Industry 4.0 and Industrial IoT

Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artificial Intelligence, Big Data and Advanced Analysis, Industrial IoT: Business Model and Reference Architecture, Business Models

Unit 5: Fog Computing

Computing-Definition Characteristics- Application Scenarios - Issues -Fog Computing and Internet of Things–Fog Computing Components, Fog Computing and Cloud Computing-Simple Case Studies (STLS and Wind Farm) -High Level and Software Architect, Fog Computing Fundamentals: Introduction –Fog Computing Basics – Fog Computing Services

Experiments:

1. Implementation of Virtual box and Kali linux
2. Understanding the IoT Security tools: burf, Nikto, dirb, Nmap, Metasploit, Brute force, Hci tools, nRF connect app
3. Packet Analysis by capturing packet using Wireshark
4. Communication protocol testing - with Wireshark and other proxy tools
5. IoT Firm level security implementation - firmware analysis static
6. Implementation of Light weight cryptographic algorithms applicable to IoT devices
7. IoT devices hacking in a WLAN - default password attack
8. Implementation of Open port scanning in IoT devices
9. Implementation of publicly available exploits like blue borne
10. Implementation of Metasploit payload and exploit
11. Implementation of edge-level security
12. Enumerating data of devices from search engines like Shodan, Fofa, Censys and Zoomeye - Docks for devices -Shodanand Zoomeye
13. Implementation of Replay attack using IoT devices

Textbook(s):

1. John R. Vacca, “Computer and Information Security Handbook”, Elsevier, 2013, ISBN: 9780128038437.
2. William Stallings, “Cryptography and Network security: Principles and Practice”, 5th Edition, 2014, Pearson Education, India, ISBN-13: 978-9332518773.
3. Maryline Laurent, Samia Bouzefrane, “Digital Identity Management”, Elsevier, 2015. ISBN: 9781785480041.

Reference(s):

1. Christof Paarand Jan Pelzl, “Understanding Cryptography –A Textbook for Students and Practitioners”, Springer, 2014. ISBN 978-3-642-04101-3
2. Behrouz A. Forouzan, “Cryptography and Network Security” McGraw Hill, 2007. ISBN: 978-0073327532
3. Charlie Kaufman, Radia Perlman, Mike Speciner, “Network Security: Private Communication in a public World”, Prentice Hall, Second Edition, 2002. ISBN: 978-0130460196

4. Parikshit Narendra Mahalle, Poonam N. Railkar, “Identity Management for Internet of Things”, River Publishers, 2015. ISBN: 9788793102903
5. Alasdair Gilchrist, “IoT security Issues”, Oreilly publications, 2017. ISBN: 9781501505621
6. Joseph Migga Kizza, “Computer Network Security”, Springer, 2005 ISBN 978-0-387-25228-5

SMART TEXTILE TECHNOLOGIES

Smart Textile Technologies	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: Microcontrollers and Interfacing / equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

The aim of the course is theoretical familiarisation with application of electronics and computing units in textile industries.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Describe the conducting fibre techniques in smart clothing.

CO2: Explain how to integrate textile antennas into wearable fabrics.

CO3: Analyse the processing of textiles and integrate electronics.

CO4: Analyse the design of wearable sensors.

CO5: Explain the various design of various smart clothes used in different applications.

CO6: Develop smart textile product prototypes using microcontrollers like Arduino effectively in a laboratory as a team/individual following the norms and document the technical information efficiently.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H						M					H	H		L
CO2	H	L					M					H	H		L
CO3	H	H					M					H	H		L
CO4	H	H					M					H	H		L
CO5	H	L					M					H	H		L
CO6		M	H	H	H	L	L	H	H	H		H	H	H	M

Course Topics:

Unit 1: Smart Electronics Textiles Basics

History of Wearable computing – Building Smart Textiles – Smart Textiles Applications – Conductive fibres for electronic textiles – Types – Applications.

Unit 2: Textile Antenna

Antenna in Textiles – Materials and fabrications – applications – Body Effects, Specific Absorption rate, antenna characteristics – Bending Effects.

Unit 3: Textile Processing and Integration of Electronics

Bulk CPYs – Polymer fibres embedded with metallic wires – Conductive fillers – Techniques for processing CPYs – fibre electronics technology – Development of chip encapsulation technique - Electronic integration on fibre level – Integration of electronics at textile level - Integration of electronics at garment level.

Unit 4: Design and Manufacture of Textile – based Sensors

Developing sensors for Smart textiles– methodology – Types, capacitance sensors, temperature sensors – manufacturing methods – Applications of textile-based sensors – fibre coated sensors.

Unit 5: Smart Clothes

Aesthetics and materiality in interaction research – Case Studies, Ice Hockey youth, design process, Solar Cell coat, concept, and design approach – Professional and Tech costumes – textile integration for medical and sports applications

Experiments:

1. Arduino IDE and sketches
2. Simple thermal sensor and measurement using Arduino
3. Social Distancing Cap implementation
4. Implementation of Thermal Incubator
5. Implementation of LED Matrix Display Badge
6. Implementation of Third Eye for The Blind
7. Implementation of Health Band
8. Implementation of Alzheimer's Assistant
9. Implementation of Smart Hand glove
10. Implementation of Smart Shirt / Cloth

Textbook(s):

1. Schneegass, Stefan, and Oliver Amft. "Smart textiles." Cham, Switzerland: Springer (2017), ISBN 978-3-319-50123-9.
2. Dias, Tilak, ed. “Electronic textiles: Smart fabrics and wearable technology” Woodhead Publishing, 2015 ISBN 978-1-84569-357-2.

Reference(s):

1. Kumar, L. Ashok Vigneswaran, C, “Electronics in textiles and clothing design, products and applications”, CRC Press, 2015, ISBN: 978-1-4987-1551-5.

EMBEDDED LINUX FOR IOT SYSTEMS WITH MOBILE APPLICATION DEVELOPMENT

Embedded Linux for IOT Systems with Mobile Application Development	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: Embedded Systems for IoT / equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

To work with Embedded Linux operating system.
To understand and apply the concepts of porting embedded linux into target platforms.
To understand various inter-process communication techniques necessary for developing applications.
To work with cross-platform applications like Ionic for Mobile Application development.

Course Outcome(s):

After completing this course, the student will be able to:
CO1: Describe the basic terms in Embedded Linux.
CO2: Understand concept of porting Embedded Linux into target platforms.
CO3: Work with threads: creation, deletion, and more with the knowledge of process synchronisation
CO4: Analyse various inter-process communication techniques necessary for developing applications.
CO5: Design mobile applications for the given requirements.
CO6: Develop Mobile Applications with the knowledge of Embedded Linux effectively for IoT applications as a team/individual following the norms and document the technical information efficiently.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H						M					H	H		L
CO2	H	L					M					H	H		L
CO3	H	H					M					H	H		L
CO4	H	H					M					H	H		L
CO5	H	L					M					H	H		L
CO6		M	H	H	H	L	L	H	H	H		H	H	H	M

Course Topics:

Unit 1: Mobile Operating Systems

Popular Mobile Platforms and their Programming Environment, Architectural overview of Android OS and Apple IoS.

Unit 2: Mobile Application Development

Introduction to Mobile Application Development, Cross Platform Applications, Ionic App Core Building Blocks, Ionic Components, Web Design Basics, Hyper Text Mark-up Language or HTML Basics of Cascaded Style Sheet or CSS, Basics of JavaScript, Basics of TypeScript, REST API Design Principle

Unit 3: Linux OS

Basic Operating System Concepts, Linux as Embedded Operating System, Comparison of Embedded OS, Embedded OS Tools and Development, Discussion on Embedded OS Applications and Products. Linux OS and Kernels.

Unit 4: Linux Commands

Linux Commands and File Permissions, Customizing Embedded Linux, Internals of Linux OS, System Calls, Linux Compiler options, Processes and Signals.

Unit 5: Threads, Process Synchronisation, and Interprocess Communication

Threads, Single and Multi-Core Systems, Serial port and Network programming, Process Synchronisation, Interprocess Communication, Pipes, FIFO and Queues, File system, Memory management, Shared Memory, Socket

Experiments:

1. Study of Ionic
2. Implementation of Apache Webserver
3. HTML, CSS Programming example
4. JavaScript Programming example
5. REST API Programming example
6. Database Programming example
7. IoT Application for Mobile Phones
8. Linux Simple Commands demonstration program
9. Linux Memory management implementation
10. Linux File Commands demonstration
11. Linux Threads study
12. Linux and Network Programming
13. IoT Embedded Mobile Project with real-time data like temperature

Textbook(s):

1. Arvind Ravulavaru, “Learning Ionic”, Packt Publishing, 2017 (Second Edition).
2. Karim Yaghmour, “Building Embedded Linux Systems” O’Reilly, 2008.

Reference(s):

1. Klaus Elk, “Embedded Software for the IoT”, De Gruyter, 2018.
2. Karim Yaghmour, “Embedded Android: Porting, Extending, and Customizing”, O’Reilly, 2013.
3. Gaurav Saini, “Hybrid Mobile Development with Ionic”, Packt Publishing, 2017.

CRYPTOGRAPHY AND NETWORK SECURITY

Cryptography and Network Security	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: Data Communication Networks / equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

To know about various encryption techniques. To understand the concept of public key cryptography. To study about message authentication and hash functions. To impart knowledge on Network security.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Classify the symmetric encryption techniques.
CO2: Illustrate various public key cryptographic techniques.
CO3: Evaluate the authentication and hash algorithms.
CO4: Discuss authentication applications.
CO5: Summarize the intrusion detection and its solutions to overcome the attacks.
CO6: Explain basic concepts of system level security.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H		M		M	M	M	H	M		L		M	L	M
CO2	M	L	H				H		L	H			M		M
CO3	M	H	M	M			M	M	M		M		M	L	M
CO4	M	H	H		M				M		M		H	L	L
Co5		M			M	M	M		M				L	L	M
CO6				M	M	H	M							M	L

Course Topics:

Unit 1: Encryption Techniques

Encryption Techniques - OSI Security Architecture, Security Components, Security Attacks, Security Services, Security Mechanisms, Services and Mechanisms Relationship, Model of Network Security, Classical Encryption techniques – Block Cipher Principles, Data Encryption Standard- Basic concepts in number theory and finite fields, Block Cipher Design Principles and Modes of Operation

Unit 2: Public Key Cryptography

Public Key Cryptography Number Theory- Public Key Cryptography, Key Establishment Protocols, Introduction, Key transport based on symmetric encryption, RSA-Key Management, Diffie-Hellman key Exchange, Quantum computers, Shor's algorithm, future demise of RSA, Quantum cryptography, Quantum key distribution and reconciliation.

Unit 3: Cryptographic and Data Integrity

Cryptographic and Data Integrity Algorithms, Interactive protocols, Touch of complexity theory, Interactive proof systems, electronic cash, Private information retrieval, Applications of cryptographic hash functions Requirements and security, Digital Signature Standard, Digital watermarking, digital fingerprinting, Steganography.

Unit 4: Network Security

Network Security Transport Level Security, Web Security, SSL, TLS, HTTPS, SSH, Time Stamping Protocol, Secure Electronic Transaction, 3-D Secure Protocol, Wireless network security, E Mail security, Electronic Money, PGP, S/ MIME, DKIM, IP Security, Introduction, GSM frequency bands, GSM PLMN,

Unit 5: System Security

System Security Intrusion detection, password management, Malicious software, Viruses and related Threats, Virus Counter measures, worms, DDoS attacks, Firewall Design Principles, Trusted Systems, Identity-Based Encryption, Firewalls, virtual private networks (VPNs), VPN Design and Architecture, best practices for effective configuration and maintenance of VPNs, encryption in firewall and VPN architectures.

Experiments:

1. Implementing Encryption Algorithms
    a. Program to understand the work of DES Algorithm
    b. Program to understand the work of AES Algorithm
2. Understanding the basis of Key exchange Algorithms
    a. Euclidean and Extended Euclidean algorithm for finding the Greatest Common Divisor of two large integers. Computing the Multiplicative inverses in Z
    b. Repeated square and multiply algorithm for modular exponentiation in Zn
    c. Chinese remainder theorem
    d. Implementing RSA Algorithm
3. Implementing Secure Hash Algorithm (SHA)
    a. MD5
    b. SHA-1
4. Implement the Signature Scheme - Digital Signature Standard
5. Implementing PGP
6. Study of Cipher using Python
    a. Hill Cipher
    b. Vigenère Cipher
7. Study of IP Access Control List using Cisco Packet Tracer or Equivalent
8. Study of Virtual Private Network using Cisco Packet Tracer or Equivalent
9. Study of Firewall using Cisco Packet Tracer or equivalent
10. Eavesdropping Attacks and its prevention using SSH - Comparison between Telnet and SSH
11. Set Up an VPN using OpenVPN Server
12. Demonstrate intrusion detection system (ids) using any tool (snort or any other s/w)

Textbook(s):

1. Wade Trappe, Lawrence C Washington, “Introduction to Cryptography with coding theory”, 2nd ed, Pearson, 2007, ISBN-10: 0131862391 ISBN-13: 978-0131862395

2. William Stallings, “Cryptography and Network security Principles and Practices”, Pearson/PHI, 4th ed, 2006, ISBN-10: 0131873164 ISBN-13: 978-0131873162

3. Atul Kahate, “Cryptography and Network Security”, McGraw Hill, 3rd Edition 2003, ISBN-13: 978-1259029882

Reference(s):

1. W. Mao, “Modern Cryptography –Theory and Practice”, Pearson Education, Second Edition, 2007, ISBN-13: 9780134171845

2. Charles P. Pfleeger, Shari Lawrence Pfleeger, “Security in Computing” Third Edition - Prentice Hall of India, 2006, ISBN-10: 0130355488 ISBN-13: 978-0130355485

STATISTICAL INFERENCE AND MACHINE LEARNING

Statistical Inference and Machine Learning	L	T	P	C
	3	0	2	4

Pre-requisite: Basic Mathematics at I year Level / equivalent
Course Type: Programme Elective
Course Category: Integrated Course

Course Objective(s):
To learn the Statistical inferences to be applies in Machine Learning; To familiarise with Machine Learning Algorithms.

Course Outcome(s):
After completing this course, the student will be able to:

CO1: Define statistical models for business analytics and use forecasting methods to support managerial, financial, and operational statistics.
CO2: Understand regression methods.
CO3: Apply the concepts of Factor analysis and Point of Estimation methods to the given data.
CO4: Explain the fundamentals of Machine Learning
CO5: Estimate the work as part of a team and implement various machine learning algorithms.
CO6: Build the technical information related to the design and analysis of Machine learning algorithms applied to datasets.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M											M		
CO2			M	M	H		H						L	H	L
CO3			L	H	H	L	H						L	H	
CO4			L	M	H	L	H						L	H	L
CO5								H	H		L				M
CO6								M	H	H		L			M

Course Topics:

Unit 1: Basic Statistics
Basic of Statistics. Data, Context and Business, Data Quality Issues, Measure of Central Tendency, Mathematical and Positional Averages, Measures of Variance, Measures of Shape, Probability, Introduction to Sampling, Hypothesis testing, Parametric and Non-Parametric Testing

Unit 2: Regression
Residuals and Plots, Regression Methods and its Applications, Repeated Measures, Linear and non-linear data handling, Weighted Least Squares, Two Stage Least Squares, Principal components Analysis, large sample inference, monitoring quality

Unit 3: Multi-Variate Analysis and Estimations
Factor analysis: Orthogonal factor model, methods of estimation, factor rotation, factor scores, perspectives, and a strategy for factor analysis, Point estimation, Exponential family of

distributions, Finite state Hidden Markov Models, Ancillary statistics, Fisher information measure and its properties

Unit 4: Fundamentals of Machine Learning

Fundamentals of Machine Learning, Types of Learning Supervised Learning Unsupervised Learning Reinforcement Learning, Classification of Machine Learning, and the algorithms, least squares optimization - Simulated annealing, The Genetic algorithm

Unit 5: Classification and Clustering Techniques

Classification Algorithms, Ensemble Methods, Sensitivity, Specificity, Positive Predictive Value, Negative Predictive Value, Lift Curves and Gain Curves, ROC Curves, Misclassification, Hierarchical Methods, Cluster Algorithms, Measuring Clustering Goodness

Experiments:

1. Measures of Central Tendency, Measures of Dispersion, Measures of Skewness
2. Hypothesis Test using one tail Test and two tail tests
3. Univariate Analysis, Bivariate Analysis, Multivariate Analysis
4. Analysis of Variance (ANOVA)
5. Linear Regression
    a. Housing Price Prediction
    b. Air Quality Prediction
6. Logistic Regression
    a. Credit Default Prediction
    b. Heart Disease Prediction
7. Dimensionality Reduction Using Factor Analysis
8. Estimating population statistics with Point Estimation
9. Program to demonstrate k-Nearest Neighbour flowers classification
10. Program to demonstrate Decision Tree – ID3 Algorithm and Random Forest with flowers classification
11. Program to demonstrate Naïve- Bayes Classifier
12. Program to demonstrate k-means clustering algorithm

Textbook(s):

1. T. Veerarajan, “Probability, Statistics and Random Processes” Tata McGraw-Hill, Education 2008(3rd Edition), ISBN: 978-0070699564
2. Robert Stine, Dean Foster, “Statistical for Business: Decision Making and Analysis”. Pearson Education, 2013(2nd Edition), ISBN: 9780321836519
3. Kevin P. Murphy, “Machine Learning – A probabilistic Perspective”, MIT Pres, 2016, *ISBN*: 9780262018029
4. Randal S, “Python Machine Learning, PACKT Publishing, 2016(3rd Edition), *ISBN*: 9781789955750

Reference(s):

1. Levin Richard and Rubin Davids, “Statistics for Management “, Pearson Publications, 2016 (Eighth Edition), ISBN. 978-9332581180
2. Robert Stine, Dean Foster, “Statistical for Business: Decision Making and Analysis”. Pearson Education, 2018 (3rd edition), ISBN: 9780134497167
3. Ethem Alpaydin, "Machine Learning: The New AI”, MIT Press, 2016, ISBN 13: 9780262529518
4. Shai Shalev-Shwartz, Shai Ben-David, "Understanding Machine Learning: From Theory to Algorithms”, Cambridge University Press, 2014, ISBN: 9781107298019
5. Sebastian Raschka, “Python Machine Learning”, Packt Publishing, 2019 (3rd Edition), ISBN: 9781789955750

DEEP LEARNING IMPLEMENTATIONS IN TENSORFLOW AND KERAS

Deep Learning implementations in TensorFlow and Keras	L	T	P	C
	3	0	2	4

Pre-requisite: Statistical Modelling and Machine Learning
Course Type: Programme Elective
Course Category: Integrated Course

Course Objective(s):

To impart knowledge about the concepts of machine learning. To introduce the fundamental concepts of distributed nature of operating system, network, data, and processes. To enable the students to understand the concepts of computing environment where computations do not take place at one system and accordingly enable them to solve related problems.

To build the foundation of deep learning. To understand how to build the neural network. To enable the students, develop successful machine learning projects.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the stochastic process in Time series analysis and survival analysis.
CO2: Understand the fundamentals of ANN and CNN with basic TensorFlow implementations.
CO3: Implement RNN and the LSTM networks.
CO4: Apply GAN Neural networks to a real-world problem.
CO5: Implement the Deep Learning concepts in TensorFlow
CO6: Identify the implementation of Memory Augmented Neural Networks to Temporal Linking of DNC

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M								L		L	M		
CO2	H	M	M	L			H			L		L	H	H	L
CO3	H	H	M	M	M	L	H			L		L	H	H	L
CO4	H	H	H	H	M	L	H			L		L	H	H	L
CO5	H	M	M	L			H			L		L	H	H	L
CO6	H	M								L		L	M		L

Course Topics:

Unit 1: Stochastic Process and Survival Analysis

Stochastic process, Time series as a discrete stochastic process, Autoregressive models. Seasonality in Box –Jenkins model, Basic Quantities and Models, Survival Analysis, Nonparametric Estimation of Basic Quantities for Right Censored and Left Censored Data, Inference for Parametric Regression Models

Unit 2: Basics of Deep Learning and Convolutional Neural Networks

Fundamentals of ANN, Tensor flow, ANN in TensorFlow, Implementation of Neural Networks, Classification of Neural Network, Classification Methods, Gradient Descent, Convolutional Neural Networks, and its implementation in Tensor flow

UNIT-3: RNN and LSTM Neural networks

Recurrent Neural Networks and its implementation in Tensor flow, Differences between various Neural network tools, LSTM Neural Networks and its implementation in Tensor flow, Examples of simple RNNs, Using LSTMs to synthesize text, Image synthesis with variational auto encoders

Unit 4: Generative Neural Networks and Advanced Neural Networks

Generative Adversarial Networks, MIMO Deep Learning models, Hyper parameter tuning, Ensemble of models, Information-Theoretic Machine Learning, Layers graphs, Types of Learning, Various types of Neural Networks and their implementation in Tensor flow. Example from medical diagnostics

Unit 5: Neural Network and its Applications

Memory Augmented Neural Networks, Neural Turing Machines, Attention-Based Memory Access- NTM Memory Addressing Mechanisms, Differentiable Neural Computers-Interference-Free Writing in DNCs-DNC Memory Reuse, Temporal Linking of DNC Writes-Understanding the DNC Read Head- The DNC Controller Network Visualizing the DNC in Action, Implementing the DNC in Tensor Flow- Teaching a DNC to Read and Comprehend.

Experiments:

1. Print Dimensions of dataset, Calculation of Accuracy Values, Accessing and Manipulation of tensors
2. Understand the mechanism of practically training a binary classifier
3. Access and manipulation of tensors, Regression Data Sampling, Combat Overfitting
4. CNN Training, reuse a model, Reusing a part of an existing model
5. CNN implementation with CIFAR-100 dataset
6. Text Generation, Automatic Image Captioning with Keras
7. Implementing a recurrent neural network (RNN) in TensorFlow
8. RNN that will generate new “Flower” names
9. Stages of the convnet, Sequence Classification Problem, Text-to-Speech synthesis
10. Implementation of GAN network in Keras
11. Bayesian Networks implementation in Keras
12. Implementing Memory Augmented Neural Networks using Keras.

Textbook(s):

1. Ethem Alpaydin, “Introduction to Machine Learning”, Pearson / Prentice Hall, 2014, ISBN: 978-8120350786

Reference(s):

1. Stephen Marsland, Chapman, and Hall, “Machine Learning: An Algorithmic Perspective”, CRC Press, 2011, ISBN: 978-1466583283
2. Christopher M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2006, ISBN 978-0-387-31073-2
3. Tom Mitchell, “Machine Learning”, McGraw Hill, ISBN: 978-1259096952
4. Ian Goodfellow, Yoshua Bengio and Aaron Courville, “Deep Learning”, MIT Press, 2015, ISBN: 978-0262035613
5. T. Hastie, R. Tibshirani, and J. Friedman, “The Elements of Statistical Learning”, Springer, 2013, ISBN 978-0-387-84858-7
6. D. Koller, and N. Friedman, “Probabilistic Graphical Models: Principles and Techniques”, MIT Press, 2009, ISBN: 978-0262013192

APPLIED DATA MODELLING AND DEEP LEARNING FOR ENGINEERS

Applied Data Modelling and Deep Learning for Engineers	L	T	P	C
	3	0	2	4

Pre-requisite: Deep Learning implementations in TensorFlow and Keras / equivalent
Course Type: Programme Elective
Course Category: Integrated Course

Course Objective(s):

To introduce the concepts of data Mining and its applications. To understand investigation of data using practical data mining tool. To introduce Association Rules Mining. To introduce advanced Data Mining.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Identify the key process of Data mining and Warehousing.
CO2: Apply appropriate techniques to convert raw data into suitable format for practical data mining tasks.
CO3: Compare various Evaluation Techniques.
CO4: Evaluate the performance of various classification methods using performance metrics.
CO5: Build real world applications using Reinforcement learning
CO6: **I**mplement appropriate algorithms and Neural Networks for various applications.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M											M		
CO2	H	M			M								M	L	
CO3		H	M	L									L	L	
CO4		H		M									L	L	
CO5	L		M		M	H		H	H		L		M	L	M
CO6	L	H		M			H	M	H	H		L	M	L	M

Course Topics:

Unit 1: Data Understanding and Preparation, Data Transformations

Identifying business objectives, translating business objectives to data mining goals, reading data from various sources – Database/ Excel/ Text/others, data visualization – tabular and graphic, distributions and summary statistics, Automated Data Preparation, Sampling cases, Partitioning data, Training, Validation and Testing, Model selection.

Unit 2: Modeling Techniques

Linear regression, Logistic regression, Discriminant analysis, Bayesian networks, Neural networks, Rule Induction, Support vector machines, Cox regression, Time series analysis, Decision trees, Clustering, Association Rules, Sequence Detection

Unit 3: Model Evaluation and Deployment

Model Validation, Determining Model Accuracy, Rule Induction Using CHAID, Automating Models, Evaluation Charts for Model Comparison, Using Propensity Scores, Error Modelling, Deploying Model, Exporting Model Results, Assessing Model Performance, Updating A

Model, few use case examples, Benefits of predictive analytics to retailers, Robots-seeing to customer satisfaction, and IoT

Unit 4: Reinforcement Learning

Reinforcement Learning, Markov decision process (MDP), Bellman expectation equations, Bellman optimality equations, Bellman expectation and optimality operators, Overview of dynamic programming for MDP, Monte Carlo Methods for Model Free Prediction and Control.

Unit 5: Advanced Reinforcement Techniques

Overview of Monte Carlo methods for model free RL, Risk minimization, Gradient MC, and Semi-gradient TD (0) algorithms, Experience replay in deep Q-Networks, Deep Reinforcement, Markov Decision Processes (MDP), Explore Versus Exploit, Policy Versus Value Learning-Pole-Cart with Policy Gradients, QLearning AND Deep Q-Networks, Improving AND Moving Beyond DQN.

Experiments:

1. Fraud detection
2. Risk modelling and investment banking
3. Customer Churn
4. Customer sentiment analysis
5. Online Retail Case Study
6. Energy Efficiency Analysis
7. Liver Disease Prediction
8. Car Price Prediction
9. Implement the Markov decision Process using Reinforcement learning
10. Build a Recommendation System Using Reinforcement Learning
11. Build a system for Dynamic Pricing using Reinforcement Learning
12. Implementation of using Q-learning

Textbook(s):

1. Dunham M H, “Data Mining: Introductory and Advanced Topics”, Pearson Education, New Delhi, 2003. 2015 ISBN: 978-0130888921
2. Jaiwei Han and Micheline Kamber, “Data Mining Concepts and Techniques”, Elsevier, 2006 ISBN: 978-9380931913

Reference(s):

1. M Sudeep Elayidom, “Data Mining and Warehousing”, 1st Edition, 2015, Cengage Learning India Pvt. Ltd. ISBN: 9788131525869
2. Mehmed Kantardzic, “Data Mining Concepts, Methods and Algorithms”, John Wiley and Sons, USA, 2003. ISBN: 978-1-119-51604-0
3. Pang-Ning Tan and Michael Steinbach, “Introduction to Data Mining”, Addison Wesley, 2006 ISBN: 978-9332571402

CYBERSPACE OPERATIONS AND DESIGN

Cyberspace Operations and Design	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: Cryptography and Network Security
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

This course provides a basic understanding of full-spectrum cyberspace operations, the complexities of the cyberspace environment, as well as planning, organizing, and integrating cyberspace operations. The course will consist of presentations and exercises that will teach students how to develop a cyber-operations design and bring it to fruition. At the conclusion of the course, students will have a fundamental understanding of how to analyse, plan for, and execute cyberspace operations.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Describe Cyberspace Environment and Design.
CO2: Explain Cyberspace Operational Approaches.
CO3: Analyse various Cyberspace Operations.
CO4: Apply Cyberspace Integration.
CO5: Build Cyber Warriors and Warrior Corps
CO6: Design Cyber Related Command

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1		L	M	L		L	H	M			L	M	M	L	L
CO2		M	M	M		L					L	M	L	H	L
CO3		L	M	H	M	M		L				M	L	H	L
CO4		L	H	H	H	H	H	H			L	H	L	H	L
CO5		L	M	H	M	M		L				M	L	H	M
CO6		M	M	M		L					L	M	L	M	L

Course Topics:

Unit 1: Cyberspace Environment and Design

Cyberspace environment and its characteristics, developing a design approach, planning for cyberspace operation, Foundational approaches that utilize cyberspace capabilities to support organizational missions, The pros and cons of the different approaches, Network Operations (NETOPS), Defensive Cyberspace Operations (DCO), Offensive Cyberspace Operations (OCO), defence and diversity of Depth network design.

Unit 2: Cyberspace Integration

Operational methodologies to conduct cyberspace operations, design a cyberspace operation, integrate it with a Joint Operations plan, Case Study of the presented methodologies in a practical application, The warrior concept applied to Cyber Organizations, the warrior corps concept applied to Cyber Organizations, the challenges of training, developing a cyber-workforce from senior leadership to the technical workforce, Designing Cyber Related Commands.

Unit 3: Cyber Related Commands

Mission statements, Essential tasks, Organizational structures, Tables of organizations, Mission Essential Tasks (METs), Developing the cyber workforce, Hacking windows – Network hacking, Web hacking – Password hacking, A study on various attacks – Input validation attacks – SQL injection attacks.

Unit 4: Ethical Hacking

Buffer overflow attacks - Privacy attacks, TCP / IP – Checksums – IP Spoofing port scanning, DNS Spoofing, Dos attacks – SYN attacks, Smurf attacks, UDP flooding, DDOS – Models. Firewalls – Packet filter firewalls, Packet Inspection firewalls, Application Proxy Firewalls. Batch File Programming, Fundamentals of Computer Fraud – Threat concepts, Framework for predicting inside attacks –Managing the threat – Strategic Planning Process, Architecture strategies for computer fraud Prevention – Protection of Web sites, Intrusion detection system – NIDS, HIDS – Penetrating testing process.

Unit 5: Digital Forensic and Security Assessment, and Testing

Web Services – Reducing transaction risks, Key Fraud Indicator selection process customized taxonomies, Key fraud signature selection Process –Accounting Forensics, Computer Forensics – Journaling and it requirements – Standardized logging criteria, Journal risk and control matrix – Neural networks, Misuse detection and Novelty detection, Introduction a brief tour of the course Setting up the testing environment - Kali Linux Overview, Static Analysis for Security, Security Testing of Web-based Systems, OS Kernel Security and Exploitation, Architecture/Design Analysis for Security Attack Patterns, Dynamic Analysis for Security, Fuzz Testing, Security Testing and Analysis for Regulatory Compliance and Standards.

Experiments:

1. Implementation of Virtual box and Kali linux
2. Understanding the IoT Security tools: burf, Nikto, dirb, Nmap, Metasploit, Brute force, Hci tools, nRF connect app.
3. Packet Analysis by capturing packet using Wireshark
4. Communication protocol testing - with Wireshark and other proxy tools
5. Cyber-Threats Trends (Ransomware)
6. Attacks and malware Eavesdropping
7. Hacking in a WLAN - default password attack
8. Implementation of Open port scanning
9. Implementation of publicly available exploits like blue borne
10. Implementation of Metasploit payload and exploit
11. Threat modelling a network
12. Setting up lab for Pen testing and installing Kali Linux
13. Implementation of Replay attack

Textbook(s):

1. Paulo Shakarian, Jana Shakarian, Andrew Ruef, “Introduction of Cyber Warfare: A Multidisciplinary Approach”, Elsevier, 2013.

Reference(s):

1. Jeffery Carr, “Inside Cyber Warfare: Mapping the Cyber Underworld,” O’Reilly Publication 2012.
3. Jason Andress, Steve Winterfeld, “Cyber Warfare: Techniques, Tactics and Tools for Security Practitioners” Elsevier 2013.
4. Richard A. Clarke, Robert Knake “Cyber War: The Next Threat to National Security and What to Do About It”, Haper Collins Publisher 2010.

APPLIED CYBER DATA ANALYTICS

Applied Cyber Data Analytics	L	T	P	X	C
	3	0	2	0	4
Pre-requisite: Statistical Inference and Machine Learning **Course Category:** Programme Elective **Course Type:** Integrated Course					

Course Objective(s):

To optimize business decisions and create competitive advantage with Big Data analytics
To explore the fundamental concepts of big data analytics.
To learn to analyse the big data using intelligent techniques.
To understand the various search methods and visualization techniques.
To learn to use various techniques for mining data stream.
To understand the applications using Map Reduce Concepts.
To introduce programming tools PIG and HIVE in Hadoop echo system.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Work with big data platform and explore the big data analytics techniques business applications.

CO2: Design efficient algorithms for mining the data from large volumes.

CO3: Analyse the HADOOP and Map Reduce technologies associated with big data analytics.

CO4: Explore on Big Data applications Using Pig and Hive

CO5: Describe the fundamentals of various big data predictive analytics techniques.

CO6: Build a complete business data analytics solution as a team/individual following the norms and document the technical information efficiently.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	L					M					H	H		L
CO2	H	L	H	L			M					H	H		L
CO3	H	H	H	L			M					H	H		L
CO4	H	H	H	L			M					H	H		L
CO5	H	L					M					H	H		L
CO6		M	H	H	H	L	L	H	H	H		H	H	H	M

Course Topics:

Unit 1: Big Data Basics

Introduction to Big Data Platform – Challenges of Conventional Systems - Intelligent data analysis – Nature of Data - Analytic Processes and Tools - Analysis vs Reporting.

Unit 2: Mining Data Streams

Introduction To Streams Concepts – Stream Data Model and Architecture - Stream Computing - Sampling Data in a Stream – Filtering Streams – Counting Distinct Elements in a Stream –

Estimating Moments – Counting Oneness in a Window – Decaying Window - Real time Analytics Platform (RTAP) Applications – Case Studies - Real Time Sentiment Analysis- Stock Market Predictions.

Unit 3: Hadoop

History of Hadoop- the Hadoop Distributed File System – Components of Hadoop Analysing the Data with Hadoop- Scaling Out- Hadoop Streaming- Design of HDFS-Java interfaces to HDFS Basics- Developing a Map Reduce Application-How Map Reduce Works-Anatomy of a Map Reduce Job Run-Failures-Job Scheduling-Shuffle and Sort – Task execution - Map Reduce Types and Formats- Map Reduce Features-Hadoop environment.

Unit 4: Frameworks

Applications on Big Data Using Pig and Hive – Data processing operators in Pig – Hive services – HiveQL – Querying Data in Hive - fundamentals of HBase and ZooKeeper - IBM InfoSphere BigInsights and Streams.

Unit 5: Predictive Analytics

Simple linear regression- Multiple linear regression- Interpretation of regression coefficients. Visualizations - Visual data analysis techniques- interaction techniques - Systems and applications

Experiments:

1. (i)Perform setting up and Installing Hadoop in its two operating modes: pseudo distributed, fully distributed. (ii) Use web-based tools to monitor your Hadoop setup
2. Implement the following file management tasks in Hadoop: Adding files and directories, retrieving files, Deleting files
3. Benchmark and stress test an Apache Hadoop cluster
4. Run a basic Word Count Map Reduce program to understand Map Reduce Paradigm.

    Find the number of occurrences of each word appearing in the input file(s)

    Performing a MapReduce Job for word search count (look for specific keywords in a file)
5. Stop word elimination problem:

    Input: A large textual file containing one sentence per line; A small file containing a set of stop words (One stop word per line)

    Output: a textual file containing the same sentences of the large input file without the words appearing in the small file.
6. Write a Map Reduce program that mines weather data.
7. Sales breakdown by product category across all the stores
8. Install and Run Pig then write Pig Latin scripts to sort, group, join, project, and filter your data.
9. Write a Pig Latin scripts for finding TF-IDF value for book dataset (A corpus of eBooks available at: Project Gutenberg)
10. Install and Run Hive then use Hive to create, alter, and drop databases, tables, views, functions, and indexes.
11. Install, Deploy and configure Apache Spark Cluster. Run Apache spark applications using Scala.

12. Data analytics using Apache Spark on Amazon food dataset, find all the pairs of items frequently reviewed together.

Textbook(s):

1. Michael Berthold, David J. Hand, “Intelligent Data Analysis”, Springer, 2007
2. Tom White “Hadoop: The Definitive Guide”, O’Reilly Media, 2012 (Third Edition).

Reference(s):

1. Chris Eaton, Dirk DeRoos, Tom Deutsch, George Lapis, Paul Zikopoulos, “Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data”, McGraw Hill, 2012
2. Anand Rajaraman and Jeffrey David Ullman, “Mining of Massive Datasets”, CUP, 2012.
3. Arshdeep Bahga, Vijay Madisetti, “Big Data Science and Analytics: A Hands-On Approach”, VPT, 2016.
4. Bart Baesens “Analytics in a Big Data World: The Essential Guide to Data Science and its Applications (WILEY Big Data Series)”, Wiley, 2014.

SECURITY DATA VISUALISATION

Security Data Visualisation	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: Cryptography and Network Security
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

To extend student's knowledge in Data Science with emphasis on Predictions utilizing associated statistical methods and software tools for security data.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the key techniques and theory behind data visualisation.

CO2: Use the various visualisation structures (like tables, spatial data, tree, and network etc.) effectively.

CO3: Evaluate information visualisation systems and other forms of visual presentation for their effectiveness**.**

CO4: Using data visualisation, assess the vulnerability of a system in network.

CO5: Explain the principles of defending visualisation systems.

CO6: Build data visualization systems as a team/individual in a laboratory using appropriate software tools following the norms and document the technical information efficiently.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	L					M					H	H		L
CO2	H	L	H	L			M					H	H		L
CO3	H	H	H	L			M					H	H		L
CO4	H	H	H	L			M					H	H		L
CO5	H	L					M					H	H		L
CO6		M	H	H	H	L	L	H	H	H		H	H	H	M

Course Topics:

Unit 1: Data Visualisation Basics

"What's Vis and Why Do It?": Why Visualize Data? – The Shapes of Data – What: Data Abstraction – Why: Task Abstraction: Inputs for Visualization Data and Tasks. Case Study Example: Charles Joseph Minard – Napoleon's Invasion of Russia. Introduction to R Programming – Creation of Basic Visualisation using R: Histogram, Bar / Line Chart, Box plot, Scatter plot.

Unit 2: Marks and Channels

Encoding Data, Rendering Marks, and Channels – Rules of Thumb: No Unjustified 3D and 2D – Arrange Tables: Reusable Scatter plot – Common Visualization Idioms: Bar Chart (Vertical and Horizontal), Pie Chart and Coxcomb plot, Line Chart, Area Chart. Case Study Example: The Cheddar Cheese Data Set – Creation of Scatter Plot Matrix (SPLOM) to analyse the taste

of Cheddar Cheese – Visualization of Spatial Data, Networks and Trees: Arrange Spatial Data, Arrange Networks and Trees.

Unit 3: Using Colour and Size in Visualisation

Map Colour and Other Channels: Encoding Data using Colour, Size; Stacked Bar Chart; Streamgraph; Line Charts with multiple lines – Creation of Advanced Visualisation using R: Heat Map, 3D graphs, Colourmaps – Interaction Techniques: Manipulate View – Panning and Zooming on a Globe – Facet into Multiple Views: Juxtapose and Coordinate views – Linked Navigation: Bird's Eye Map – Reduce Items and Attributes: Filter and Aggregate. Case Study Exercise using R: Impact of Vaccines on battling Infectious diseases (Source: Benefits from Immunization During the Vaccines for Children Program Era — United States, 1994–2013).

Unit 4: Port Scan Visualisation, Vulnerability Assessment

Internet Protocol Overview – Visualising Port scans – Nessus – Metasploit – Analysing the ISP Dataset.

Unit 5: Intrusion Detection Log Visualisation, Defending Visualising Systems

Intrusion Detection Signature with Tree maps, analysing tree maps, attacking a security visualising system, defending system, creating a security visualisation system.

Experiments:

1. Data visualization workflow study
2. Data Representation: chart types: categorical, hierarchical, relational, temporal, and spatial; 2-D charts
3. 3D mapping; multi-dimensional data visualization; manifold visualisation, graph data visualization

Visualisation of static data.

4. Visualisation of web data.
5. Visualisation of sensor data.
6. Visualisation of protein data.
7. Implement linear regression techniques
8. Visualize the clusters for any synthetic dataset.
9. Implement the program for converting the clusters into histograms.
10. Simulation and visualization of different types of traffic-congestion controlled and non-congestion controlled.
11. Trace analysis and visualization of protocol dynamics {throughput; packet drop, buffer dynamics, congestion window, round-trip-time, bandwidth delay product, receiver window, etc.}

Textbook(s):

1. Tamara Munzner, "Visualization Analysis and Design: A K Peters Visualization Series", CRC Press, 2014
2. Greg Conti, "Security Data Visualization: Graphical Techniques for Network Analysis", No Starch Press, 2007.

Reference(s):

1. Scott Murray, "Interactive Data Visualization for the Web", O'Reilly, 2013.

2. Alberto Cairo, “The Functional Art: An Introduction to Information Graphics and Visualization”, New Riders, 2012
3. Nathan Yau, “Visualize This: The Flowing Data Guide to Design, Visualization and Statistics”, Wiley, 2011.
4. Raffael Marty, “Applied Security Visualization”, Addison-Wesley, 2009.

ASIC DESIGN FLOW

ASIC Design Flow	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: Digital Circuits and Systems Design /equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

To learn about the various ASIC architectures, ASIC design flow; To familiarise with terminologies related to ASIC design flow while interacting with peers; List the various input and output files and its formats for each step in the flow.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Explain ASIC and its various types.
CO2: Explain the importance of SV and UVM design methodologies.
CO3: Describe the challenges in implementing large ASIC designs and generating the gate level netlist.
CO4: Apply the basic concepts of STA to evaluate the delay of the circuits and analyse the generated report.
CO5: Understand the issues involved in PnR flow of ASIC design.
CO6: Communicate the technical information related to design of digital circuits using Verilog and analyse different timing paths in STA.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H		M	M	H								H	M	
CO2	H				L	L	L						H	M	
CO3		M	M		M			L	L			H	H	M	L
CO4	M				M				L			H	H	M	L
CO5		M		M	M	L	L		L			H	H	M	L
CO6					M			L	M	H	M	H		H	L

Course Topics:

Unit 1: RTL Design, Verification using Verilog

Introduction to ASIC flow, Specification, architecture and micro-architecture RTL design, Arithmetic and Logical Operators, Relational and Equality Operators, Bitwise and Reduction Operators, Conditional Operators, Dataflow, structural and behavioural modelling, Continuous(assign) statements and procedural assignments, Synchronous Circuits theory, Implementation of different modelling methods, Verification plan.

Unit 2: RTL Design using SV, CDC and Linting

Implementation of verification method –Verilog, Introduction to SV and UVM, Verification environment using SV and UVM, Comparison between Verilog and SV constructs - basic data types, Comparison between Verilog, and SV constructs – loops, Analysis of GLN, Gate level simulation (GLS), Linting and CDC checks.

Unit 3: Synthesis, Design for Test and Static Timing Analysis

Emulation (prototyping on FPG), Introduction to logic synthesis, preparing for synthesis, compiling a design, Optimisation flow and optimisation techniques, DFT, terminologies, types of scan faults, Implementation of DFT, Introduction to LEC, Introduction to STA, Terminologies in STA, delay calculation in combo path.

Unit 4: Library and Characterisation

Delay calculation in sequential path and combinational path, Introduction to library and characterization, characterization methods and techniques, Modelling of characterised data**.**

Unit 5: Auto Place and Route Flow

Introduction to APR flow, Floorplan and powerplan, Routing concepts and introduction to DFM, LEC post layout, ECO flow, Parasitic Extraction, Post-layout STA and Back-annotation, Physical verification, and tape out.

Experiments:

1. Write a Verilog code to implement the specified functionality and verify the functionality
2. Write an RTL code to design a full adder circuit and verify the functionality
3. Write an RTL code to design a comparator circuit and verify the functionality
4. Write an RTL code to design all basic flops and verify the functionality
5. Write an RTL code to design a 3 bit up/down counter and verify the functionality
6. Write an RTL code to design a shift register circuit and verify the functionality
7. Generate the netlist file using the synthesis tool - creating the setup files
8. Generate the netlist file using the synthesis tool - execution
9. Generate a schematic from gate level netlist
10. Load a netlist and understand all the basic commands of STA tool
11. STA - Analyse the timing reports of combo path
12. STA - Apply the constraints to meet the given specification
13. Apply the additional timing constraints related to input and output delays
14. Analyse the setup and hold timing reports of reg-reg timing path
15. Analyse the setup and hold timing reports of in-out, in-reg timing path

Textbook(s):

1. Sandip Kundu, Aswin Sreedhar, “Nanoscale CMOS VLSI Circuits: Design for Manufacturability”, McGraw Hill, 2010, ISBN: 978-0071635196

Reference(s):

1. Harry Bleeker, Peter van den Eijnden, Frans de Jong, “Boundary-Scan Test: A Practical Approach”, Springer, 2011, ISBN: 978-1-4613-6371-2.
2. Himanshu Bhatnagar, “Advanced ASIC Chip Synthesis”, Springer, 2012, ISBN: 0-7923-7644-7
3. Khosrow Golshan, “Physical Design Essentials: An ASIC Design Implementation Perspective”, Springer, 2007, ISBN: 978-0-387-36642-5.

STATIC TIMING ANALYSIS

Static Timing Analysis	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: ASIC Design Flow / equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

To apply concepts and perform timing calculations for simple circuits; To familiarise with industry standard timing analysis tools to perform setup timing analysis for complex designs: Use terminologies effectively while communicating with peers in the industry: To analyse timing reports from a timing analysis tool.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Explain the concepts behind Timing Analysis and use of Static Timing Analysis (STA) in context with the ASIC flow.
CO2: Analyse the importance of design constraints.
CO3: Describe the need for timing exceptions.
CO4: Define various steps to fix timing violations.
CO5: Identify different signal integrity issues.
CO6: Communicate the technical information related to analysing different timing paths and reports.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M			M				M				H	M	
CO2	H	M	M	M	M	L	L						H	M	
CO3	H	M	M	M	M			L					H	M	
CO4	H	M	M	M									H	M	
CO5	H	M	M	M				L	M			H	H	M	L
CO6	H	M	M	M					M	M	M	H	H	M	L

Course Topics:

Unit 1: Fundamentals of STA

Introduction to timing analysis, Terminologies used in STA, delay calculation in combinational logic, Introduction to design and technology data, Design and library objects, delay calculation in sequential circuit, inputs and outputs of STA, Clocks and their characteristics, Analysis of reg-reg, in-reg and reg-out delay calculation.

Unit 2: Timing constraints in STA

Timing constraints, Environmental attributes, Applying timing constraints, Additional timing constraints, Different timing paths, Introduction to timing exceptions, back annotation, Reg-reg with diff clock frequency.

Unit 3: Additional Timing Constraints in STA

Applying additional timing constraints, PVT variations and their effect on timing, timing reports, Virtual clock with in-out path and in-reg path, Multi cycle paths, Multiple clocks and exceptions, effects of clock skew on timing

Unit 4: Advanced Concepts in STA

Fixing timing violations, advanced concepts in STA, Examples on fixing timing violations, Reg-reg with diff clock edge, Reg-reg with slew propagation, multicycle path, Reg-reg with CRPR, with inverting clock at capture path**.**

Unit 5: Signal Integrity and Back Annotation

Signal integrity and timing models, setup and hold times of flops, Latch-reg path, Reg-latch path, Latch-latch with diff clock edge path, Analysing parasitic extraction and back annotation.

Experiments:

1. Load a netlist and understand all the basic commands of STA tool.
2. Using STA tool calculate the cell delay and o/p transition for a given load and given transition.
3. Load a netlist and apply the constraints related to clock and input/output delays in STA tool.
4. Apply the timing constraints to meet the given specification and validate the constraints.
5. Apply the timing constraints related to input transition and load and validate the constraints.
6. Apply the additional timing constraints related to input and output delays.
7. Apply the constraints related to exceptions and analyse the constraints report and timing report.
8. Analyse the setup and hold timing reports of in-out, in-reg timing path.
9. Analyse the setup and hold timing reports of latch-latch, reg-out timing path.
10. Analyse the setup and hold timing reports of reg-reg diff clock edge, generated clock, half cycle timing path.
11. Analyse the setup and hold timing reports of reg-reg multi cycle, positive-negative skew timing path.
12. Analyse the setup and hold timing reports of reg-reg CRPR, uncertainty timing path

Textbook(s):

1. Sachin Sapapnekar, “Timing”, Springer 2013, ISBN: 978-1441954084

Reference(s):

1. Yuan Taur and Tak H. Ning, “Fundamentals of Modern VLSI Devices”, Cambridge University Press, 2013
2. Synopsys tool manuals PrimeTime® Fundamentals User Guide λ PrimeTime® Advanced Timing Analysis User Guide Library Compiler ™ Timing, Signal Integrity and Power Modelling User Guide.
3. J. Bhasker, Rakesh Chadha, “Static Timing Analysis for Nanometre Designs: A Practical Approach”, Springer, 2009, ISBN: 978-0387938196.

DESIGN FOR TESTABILITY

Design For Testability	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: ASIC Design Flow / equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

To have knowledge about various faults and modelling of the faults in digital systems. To learn about various methods to detect the faults in combinational and sequential systems. To provide knowledge about designing of Testable system designs.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Detect faults occurring in digital systems and modelling of the faults.
CO2: Analyse fault simulation, test generation and fault diagnosis.
CO3: Recognize the BIST techniques for improving testability.
CO4: Integrate DFT structure in RTL.
CO5: Understand the importance of emulation.
CO6: Communicate the technical information related to DRC issues in DFT modelling.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M	M	M	L				L				H	M	
CO2	H	M	M	M		L	L						H	M	
CO3	H	M	M	M				L				H	H	M	L
CO4	H	M		M	L				L			H	H	M	L
CO5	H	M	M	M	L					L		H	H	M	L
CO6									M	M	M	H			M

Course Topics:

Unit 1: DFT Basics

Why DFT, Functional Versus Manufacturing pattern, commonly used terms, Defects and Faults, Fault Modelling, Types of Faults, ATPG and D-Algorithm, DPPM, Yield management, Scan types, Scan operation (Shift-Capture), Scan insertion, Top-down and Bottom-Up approach, Design rule Checking, Handling Multiple clock domain, Balancing scan chain, Chain depth Vs Number of scan chain.

Unit 2: Test Compression and Test Protocol

Need of compression TAT and TDC, Compressor Ratio, Compressors/De-Compressor, X-Masking, On Chip Clocking for At Speed, Bypass mode, Creating Test Protocol, Test Coverage and Fault Coverage, Coverage Analysis, Pattern generation.

Unit 3: Pattern Generation, Memory Testing and Board Testing with JTAG

At Speed Pattern, LoS and LoC, Path Delay, Pattern validation, Basic memory model, Memory faults, Memory algorithm, Memory test methods, Direct memory access, Memory BIST, MBIST operation, MBIST controller + comparator, MBIST modes, Memory test waveform, MBIST pros and cons, Programmable BIST, JTAG board test, Boundary SCAN, Tap Controller, Tap Registers, and Instructions.

Unit 4: DFT in RTL, Formal Verification and STA Basics

RTL DRC, Integrating DFT Structure in RTL, Synthesizing with constraints, Introduction of Formal verification, Usage, Debugging, Introduction to STA, Introduction to SDC.

Unit 5: STA for DFT, Simulation and Scripting

Shift, Capture SDC, MBIST SDC, Boundary Scan SDC, Introduction to Synthesis and QoR, Simulation concepts, converting patterns to Verilog and validating, Debugging simulation failures, Introduction to Emulation, Introduction to scripting for DFT.

Experiments:

1. Cleaning up DFT-DRC for a design
2. Coverage analysis for a design with DFT implemented
3. Stuck-at Pattern generation
4. At-Speed Pattern generation
5. Memory grouping to achieve optimal Power and best test time
6. Implementing Boundary Scan for a design
7. Validate DC parametric, Implement the design rules for controlling Scan Mode
8. Implement DFT on an RTL
9. Explore Formal Verification of an RTL and netlist
10. Timing analysis of a design with DFT
11. Synthesis a design with DFT
12. Setting up the simulation environment for a design

Textbook(s):

1. N. Jha and S.D. Gupta, “Testing of Digital Systems”, Cambridge, 2003.

Reference(s):

1. W. W. Wen, “VLSI Test Principles and Architectures Design for Testability”, Morgan Kaufmann Publishers. 2006.
2. P.K. Lala, “Digital Circuit Testing and Testability”, Academic Press, 2002.

PHYSICAL DESIGN AND VERIFICATION

Physical Design and Verification	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: ASIC Design Flow / equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

To understand the concepts of Physical Design Process such as partitioning, Floorplanning, Placement and Routing. Verifying and validating the integrated circuit layout design.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Describe the goals, objectives, measurements, and algorithms of floorplanning and power planning.

CO2: Discover solutions for the congestion issues of physical design flow of an ASIC.

CO3: Define efficient algorithms to synthesize the clock tree and explain the challenges in the flow.

CO4: Apply the algorithms to route the signals efficiently.

CO5: Explain the importance of parasitic extraction and generate GDSII File for fabrication of an ASIC.

CO6: Communicate the technical information related to the different steps in the PnR flow efficiently.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M	M	M	M			L		L		L	H	M	
CO2	H	M	M	M	M	L	L			L		M	H	M	
CO3	H	M	M	M	L							L	M	M	
CO4	H	M	M	M	L			L	L		H	M	M	M	L
CO5	H	M	M	M	L					L	H	M	M	M	L
CO6	M	M	M	M				M	M	M	H	M	M	M	L

Course Topics:

Unit 1: APR Flow Basics

Introduction to PnR flow, design setup, floorplan, Block and chip level floorplan, data required for floorplan, I/O placement, pin placement, I/O bus architecture, Power plan, Analysing floorplan and powerplan.

Unit 2: Floorplan and Placement

App options and commands related to floorplan and powerplan, STA concepts related to timing path, analysing timing report after floorplan, Placement concepts, Analysing timing report after placement.

Unit 3: CTS Concepts

CTS concepts, CTS commands, CTS issues and analysis of timing reports, Tcl scripting basics.

Unit 4: Routing and DFM Issues

Tcl scripting for PnR flow, Routing concepts, DFM and antenna, antenna fix issues, Routing commands, Issues in routing stage.

Unit 5: Parasitic Extraction and Physical verification

Signoff, LEC post layout and ECO flow, Parasitic Extraction, Physical verification, and tape out, Techniques to extract parasitic and fix physical verification issues, MSCTS, low power VLSI.

Experiments:

1. Create a block level floorplan for the given netlist to meet the guidelines of floorplan - analyse the scripts
2. Create a block level floorplan for the given netlist to meet the guidelines of floorplan - execute
3. Create a power plan for the given floorplan block
4. Troubleshoot the DRC errors, analyse the timing report and conduct pre-placement checks
5. Implement the placement stage of the APR flow ---- analyse the setup files
6. Implement the placement stage of the APR flow ---- execute and understand the timing reports
7. Implement the CTS stage of the APR flow ---- analyse the setup files
8. Implement the CTS stage of the APR flow ---- execute and understand the timing reports
9. Run the routing stage of the APR flow ------- analyse the setup files
10. Run the routing stage of the APR flow ----- execute and check for DRC, LVS errors
11. Parasitic extraction and back annotation
12. Physical verification and tape out

Textbook(s):

1. Naveed A Sherwani, “Algorithms for VLSI Physical Design Automation”, Springer, 2013

Reference(s):

1. Harry Veendrick, “Nanometre CMOS ICs: From Basics to ASICs.”, Springer, 2017.
2. https://solvnet.synopsys.com
3. R Drechsler, “Evolutionary Algorithms for VLSI CAD”, Kluwer Academic Publishers, 2010.

LOW POWER LOGIC SYNTHESIS METHODOLOGIES

Low Power Logic Synthesis Methodologies	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: ASIC Design Flow / equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

Coverage of different aspects of the digital VLSI circuit design with particular emphasis on low-power aspects. Enable a student to meet the needs of low power and energy efficient design in EDA industry.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Recall fundamental low power design concepts to classify power dissipation mechanisms in CMOS ICs.

CO2: Classify various power optimisation techniques at circuit and logic level.

CO3: Analyse different architectural level low power transforms and logic synthesis techniques.

CO4: Analyse various power measurement and estimation techniques at different levels of abstraction and hence design power aware circuits.

CO5: Design special circuits like clock generator optimised for low power consumption.

CO6: Design a complete low power IC for the given specifications as a team/individual following the norms and document the technical information efficiently.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H												H		
CO2	H												H		
CO3	H	H	H	L			M					H	H		L
CO4	H	H	H	L			M					H	H		L
CO5	H	L	H	L			M					H	H		L
CO6		M	H	H	H	L	L	H	H	H		H	H	H	M

Course Topics:

Unit 1: Low Power Design Basics

Need for low power VLSI chips, Sources of power dissipation on Digital Integrated circuits, Physics of power dissipation in CMOS devices, Dynamic dissipation in CMOS, leakage power dissipation, Impact of technology Scaling, Technology and Device innovation.

Unit 2: Power Optimisation

Logical Level Power Optimization: gate reorganization, local restructuring, signal gating, logic encoding, state machine encoding, pre-computation logic. Circuit Level Power Optimization: transistor and gate sizing, equivalent pin ordering, network restructuring and re-organization, special latches, and flip-flops.

Unit 3: Synthesis and Software Design for Low Power

Synthesis for low power: behavioural level transforms, algorithm level transforms for low power, architecture driven voltage scaling, power optimization using operation reduction, operation substitution. Software design for low power: gate level, architecture level, bus switching activity.

Unit 4: Power Estimation

Simulation Power analysis: SPICE circuit simulators, gate level logic simulation, capacitive power estimation, static state power, gate level capacitance estimation, data correlation analysis in DSP systems, Probabilistic power analysis: Random logic signals, probability and frequency, probabilistic power analysis techniques.

Unit 5: Low Power Clock Distribution

Power dissipation in clock distribution, single driver Vs distributed buffers, zero skew Vs tolerable skew, Various clock distribution networks.

Experiments:

1. Design a full adder circuit optimised for low power consumption and verify the functionality
2. Design a comparator circuit optimised for low power consumption and verify the functionality
3. Design a multiplexer circuit optimised for low power consumption and verify the functionality
4. Design an encode circuit optimised for low power consumption and verify the functionality
5. Design a decoder circuit optimised for low power consumption and verify the functionality.
6. Design a multiplier circuit optimised for low power consumption and verify the functionality
7. Design a demultiplexer circuit optimised for low power consumption and verify the functionality
8. Design a flip-flop optimised for low power consumption and verify the functionality
9. Design a 3 bit up/down counter optimised for low power consumption and verify the functionality
10. Design a shift register circuit optimised for low power consumption and verify the functionality

Textbook(s):

1. Gary Yeap, “Practical Low Power Digital VLSI Design”, Kluwer Academic Publishers, 2002.
2. Kaushik Roy, Sharat Prasad, “Low-Power CMOS VLSI Circuit Design” Wiley, 2000.

Reference(s):

1. Rabaey and Pedram, “Low power design methodologies” Kluwer Academic, 1997.
2. Kait-Seng Yeo, Kaushik Roy, “Low-Voltage Low-Power VLSI subsystems” McGraw-Hill, 2009.
3. A. P. Chandrakasan, R.W. Broadersen, “Low Power Digital CMOS Design”, Kluwer, 1995.

HIGH LEVEL SOC DESIGN METHODOLOGIES

High Level SoC Design Methodologies	L	T	P	X	C
	3	0	2	0	4

Pre-requisite: Digital Circuits and System Design / Equivalent
Course Category: Programme Elective
Course Type: Integrated Course

Course Objective(s):

Today, VLSI chips are entire "system-on-chip" designs, which include processors, memories, peripheral controllers, and connectivity sub-systems. The course aims to provide an appreciation for the motivation behind SoC design, the challenges of SoC design, and the overall SoC design flow.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Describe basics of System on Chip.
CO2: Analyse the various methods of interconnections in a SoC.
CO3: Apply IP based system design concepts while designing systems for given requirements.
CO4: Explain about RTOS and other factors associated with SoC implementation.
CO5: Apply the testing process in the design SoC.
CO6: Document the experiments carried in Laboratory efficiently.

Mapping of Course Outcome(s):

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M	L									M	H	L	
CO2	H	H	M				M					M		M	M
CO3	H	H	M									M	H		
CO4	H	H	H				M					M	H	M	
CO5	H	H	M					L				M	H	M	
CO6				M	H	H	M	M	H	H	M	M	H	H	M

Course Topics:

Unit 1: SoC Basics

Driving Forces for SoC - Components of SoC - Design flow of SoC Hardware/Software nature of SoC - Design Trade-offs - SoC Applications System-level Design: Processor Selection- Concepts in Processor Architecture: Instruction set architecture (ISA), elements in Instruction Handing-Robust processors: Vector processor, VLIW, Superscalar, CISC, RISC—Processor evolution: Soft and Firm processors, Custom-Designed processors- on-chip memory.

Unit 2: Interconnection

Linear regression, Logistic regression, Discriminant analysis, Bayesian networks, Neural networks, On-chip Buses: basic architecture, topologies, arbitration and protocols, Bus standards: AMBA, Core Connect, Wishbone, Avalon - Network-on-Chip: Architecture-

topologies-switching strategies - routing algorithms flow control, Quality-of-Service- Re-configurability in communication architectures.

Unit 3: IP Based System Design

Introduction to IP Based design, Types of IP, IP across design hierarchy, IP life cycle, Creating and using IP - Technical concerns on IP reuse – IP integration - IP evaluation on FPGA prototypes.

Unit 4: SoC Implementation

Overview, Measures of Query Cost Selection Operation, Sorting, Join Operation, Other Operations Study of processor IP, Memory IP, wrapper Design - Real-time operating system (RTOS), Peripheral interface and components, High-density FPGAs - EDA tools used for SOC design.

Unit 5: SoC Testing

Manufacturing test of SoC: Core layer, system layer, application layer-P1500 Wrapper Standardization-SoC Test Automation (STAT).

Experiments:

1. Implementation of basic SoPC using tools.
2. Interfacing with peripherals.
3. Creation of custom peripherals using HDL.
4. Enhancement of instruction set with custom instruction.
5. Optimising system architecture through choice of processor enhancements
6. Architecture exploration of SoC Design
7. Developing tests for SoC design
8. Developing a module in SOC Design
9. Integration of SoC Design
10. Compilation in SoC design of a product

Textbook(s):

1. Michael J. Flynn, Wayne Luk, “Computer system Design: System-on-Chip”, Wiley-India, 2012.
2. Sudeep Pasricha, Nikil Dutt, “On Chip Communication Architectures: System on Chip Interconnect”, Morgan Kaufmann Publishers, 2008.

Reference(s):

1. W. H. Wolf, “Computers as Components: Principles of Embedded Computing System Design”, Elsevier, 2008.
2. Patrick Schaumont “A Practical Introduction to Hardware/Software Co-design”, 2nd Edition, Springer, 2012.
3. Lin, Y-L. S. (ed.), “Essential issues in SOC design: designing complex systems-on-chip. Springer, 2006.
4. Wayne Wolf, “Modern VLSI Design: IP Based Design”, Prentice-Hall India, Fourth edition, 2009.

DIGITAL SIGNAL PROCESSORS AND APPLICATIONS

ECE21RXXXX	Digital Signal Processors and Applications	L	T	P	X	C
		3	0	2	0	4
Pre-requisite	:	Digital Signal and Image Processing / Equivalent				
Course Category	:	Programme Elective				
Course Type	:	Integrated Course				

Course Description:

The course is intended for students to apply their knowledge on digital signal processing concepts in TMS320C5x and TMS320C6x processors. They will learn about the processor architecture, instructions, addressing modes and how to compile the assembly programs in code composers. The students will have an experience by learning in laboratory setting where they can appreciate the concepts of DSP through real - time implementation of experiments and projects.

Course Objective:

To teach students about the need for digital signal processors, latest processors, its architecture, peripheral controls, and interfacing units so that they can apply their knowledge about digital signals in TMS320C5x and TMS320C67x processors and analyse their implementation for real time applications.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Understand the need for DSP processors and analyse the output through code composers.
- **CO2 :** Illustrate the architectures of fixed- and floating-point processors
- **CO3 :** Implement basic concepts in Digital Signal Processors
- **CO4 :** Demonstrate the hardware units of the processors in interfacing the simulated output
- **CO5 :** Implement real-world applications in TMS processors.
- **CO6 :** Analyse the DSP problems as a team in targeted digital signal processors and document the same by means of oral/written reports

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	L			L								H		
CO2	H	M	L		L								H	M	
CO3		M			M		L		L				M	M	
CO4	H	H			L							H	H	M	
CO5	H	H			L		M		L			H	H	M	

CO6			L	L	L			H	H	H				M	L

Course Topics:

Unit 1: Digital Signal Processors

Need for Programmable DS Processor – Real-time Signal Processing - Multiplier and Multiplier Accumulator – Modified Bus structures and Memory access schemes – Multiple Access Memory, Multiported Memory – VLIW Architecture – Pipelining and Parallelism – On-Chip Peripherals – Specialised Instruction set and specialised addressing modes – Choosing the Digital Signal Processor: Arithmetic Format, Data Width, Speed, Memory Organisation, Ease of Development, Power Consumption and Management – Commercially available Digital Signal Processors – The TMS320 Family – Modern Digital Signal Processor Scenario: SoC with Digital Signal Processor, DSP as co-processor to Microcontroller / Microprocessor, Hybrid architectures

Unit 2: Fixed-Point, Floating-Point DSP Architectures

TMS320C50: Architecture, Buses, On-Chip Memory, On-Chip Peripherals -TMS320C67x family: Architecture. On-chip peripherals. Memory and Buses, - Digital Signal Processing Kits (DSK): Overview of TMS320C50 DSK, Overview of TMS320C6713 DSK, Overview of OMAP L138/6748 DSK and DM6437 Digital Video Development Kit

Unit 3: DSP Fundamentals and Implementation

Review of DSP fundamentals – Implementation of Sum of Products in C for Digital Signal Processors – Implementation of FIR filter in C for TMS processor – Implementation of FFT in C for TMS processor

Unit 4: On-chip Peripherals, Interfacing

Clock generator with PLL, Serial port. McBSP, Parallel port, DMA, EMIF, I^2C, Real timeclock (RTC), Watchdog timer, Serial Interface, Codec, AD and DA interfaces, MATLAB coder interface

Unit 5: DSP Tools and Applications

Digital Signal Processor Application areas and examples: DTMF signal detection using correlation and FFT - Music Beat Detection Using Onboard LEDs - Voice Detection and Reverse Playback - Speech Synthesis using Linear Prediction of Speech Signals for speech to text conversions.

Laboratory Experiments:

1. Using MATLAB, design the digital filter for the given requirements and analyse the same in time domain and frequency domain.
2. Use code composer studio with DSK6713 and DSK50 board
3. Connect Hardware and Software tools of TMS320C6748 – Generate sine wave using 48 points with output recorded in a buffer and plot it.
4. Illustrate input output operations using polling function on TMS320C6748.
5. Illustrate input output operations using interrupt on TMS320C6748.
6. Illustrate input output operations using DMA on TMS320C6748.
7. Implement Convolution on TMS320C6748.

8	Generate sine wave using Wavetable in C language for TMS320C6713 and apply it in the Amplitude Modulator / Frequency Modulator / Ring Modulator
9	Compute the dot products between arrays using code composer in C language for TMS320C6713
10	Illustrate input output operations using polling function, interrupt on TMS320C6713 in C language.
11	Implement a real-time DSP system for the given requirements on Audio Signal (with and without noisy signal) using OMAP – L138 / C6748 DSP kit (OR) DSK6713.
12	Conduct an experiment for real time Camera recording using DM6437 Digital Video Development Kit

Textbooks:

1. B. Venkataramani and M Bhaskar, "Digital Signal "Processors, McGraw Hill India, 2017 (Second Edition).
2. Reay, Donald, "Digital Signal Processing and Applications with the TMS320C6713 and TMS320C6416 DSK", Wiley, 2011 (Second Edition).
3. Reay, Donald S, "Digital signal Processing and Applications with the OMAP-L138 eXperimenter", Wiley, 2012.
4. Texas Instruments TMSC5x, C54x and C6x User's Manuals (Online).

References:

1. S. M. Kuo and W. S. S. Gan, "Digital Signal Processors: Architectures, Implementations, and Applications", Prentice Hall, 2015 (Second Edition).
2. Welch, T. B., Wright, C. H., and Morrow, M. G, "Real-time Digital Signal Processing from MATLAB to C with the TMS320C6x DSPs", CRC Press, 2017 (Third Edition).
3. Kuo, Sen M., Bob H. Lee, and Wenshun Tian, "Real-time Digital Signal Processing: Fundamentals, Implementations, and Applications", Wiley, 2013
(Third Edition).
4. Hu, Yu Hen, "Programmable Digital Signal Processors: Architecture: Programming, and Applications", CRC Press, 2001 (Second Edition).
5. Phil Lapsley and Jeff Bier, "DSP Processor Fundamentals: Architectures and Features", Wiley, 2009 (Second Edition).

BIOMEDICAL SIGNAL PROCESSING

ECE21RXXX	Biomedical Signal Processing	L	T	P	X	C
		3	0	2	0	4
Pre-requisite	**:**	Digital Signal and Image Processing / Equivalent				
Course Category	**:**	Programme Elective				
Course Type	**:**	Integrated Course				

Course Description

This course illustrates techniques of signal processing to the analysis and processing of biomedical signals. The course reinforces concepts and techniques in signal processing and introduces common biomedical signals (action potentials, EMG, ECG, EEG, heart, and respiratory signals).

Course Objective:

- To introduce origin and characteristics of biomedical signals
- To provide an understanding on the application of signal processing concepts in analysing biomedical signals
- To implement algorithms for various biomedical signal processing tasks

Course Outcomes:

At the end of the course, the student will be able to:

CO1 : Understand the origin of various bio-medical signals.

CO2 : Identify appropriate algorithms according to nature of the signal and acquisition characteristics.

CO3 : Apply the digital signal processing and statistical techniques in developing algorithms for biomedical applications.

CO4 : Develop contemporary algorithms to address complex problems involving biomedical systems meeting the environmental, health and economic considerations

CO5 : Implement the biomedical signal processing algorithms using appropriate software tools.

CO6 : Summarize laboratory findings of Bio-medical signal processing algorithms with observations and interpretations.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	L	H			L	L		L						L	
CO2	L	H	M	M	L							M	L	L	
CO3	H	M	H	M	H			L	H	M		M	H	H	
CO4	M	H	H	H	H	M	M	M	H	M	L	M	L	H	L

CO5	L		L	H	H				H	H				H	
CO6				M	M		L	H	H	H				M	

Course Topics

Unit 1: Biomedical Signal Processing Basics

Objectives of Biomedical Signal Processing, The action potential of a cardiac myocyte, The action potential of a neuron, Various Biomedical Signals: ENG, EMG, ECG, EEG, EGG, PCG, Event related potentials (ERPs), The carotid pulse, Signals from catheter-tip sensors, Bio acoustic signals, Difficulties in Biomedical Signal Analysis, Review of signal processing

Unit 2: Filtering for Removal of Artifacts

Random, Structured, and Physiological Noise, Noise in event-related potentials, High frequency noise, Motion artifact, Powerline interference, Maternal interference, Need for filtering, Linear shift in variant filters, Time domain and Frequency domain Filters, Removal of high frequency noise using Butterworth low pass filters, Removal of low frequency noise using Butterworth high pass filters, Removal of periodic artifacts: Notch and comb filters, Order-statistic filters, Adaptive Filters for Removal of Interference

Unit 3: Frequency Domain Characterization

Estimation of PSD: periodogram, need for averaging, use of windows, Estimation of ACF, Measures derived from PSD's, Moments of PSD functions, Spectral power ratios, Applications: Spectral analysis of EEG Signals

Unit 4: Detection of Events

Detection of Events and Waves, The P, QRS, and T waves in the ECG, EEG rhythms, waves, and transients, Derivative based methods for QRS detection, The Pan–Tompkins algorithm for QRS detection, Correlation Analysis of EEG Rhythms, Template matching for EEG spike and wave detection, Cross-spectral Techniques, The Matched Filter, Homomorphic Filtering, Approximation of a signal using wavelets, Empirical mode decomposition, Principal component analysis, independent component analysis.

Unit 5: Pattern Classification and Diagnostic Detection

Supervised Pattern Classification: Nearest neighbour rule, Unsupervised Pattern Classification, Probabilistic Models and Statistical Decision, Logistic Regression Analysis Measures of Diagnostic Accuracy and Cost, Reliability of Features, Classifiers, and Decisions, Case Study: Classification using the K-Means method

Laboratory Experiments:

1 Analyse the Relationship between Parameters of the EMG Signal and Muscular Force using MATLAB
2 Frequency-domain Analysis of Biomedical Signals using MATLAB
3 Design a filtering for the ECG signal for the Removal of the 60 Hz Power-line Artifacts using MATLAB
4 Design a Filter for the Removal of Noise in ECE signals using MATLAB
5 Design a Wiener Filter for ECG Signals using MATLAB
6 Analyse of Heart Sounds in frequency domain using MATLAB
7 Analyse PSD of the EEG signals using MATLAB

8 Detection of the QRS and Parameterization of the ECG signals using MATLAB
9 Design a matched filter to detect spike in EEG signals using MATLAB
10 Design of a matched filter to detect wave complexes in EEG signals using MATLAB
11 Design and analysis of the Relationship between Parameters of the EEG Signal and Sleep Stage
12 Implement Morphological Analysis and Pattern Classification of ECG Signals using MATLAB

Textbooks:

1. R M Rangayyan, "Biomedical Signal Analysis: A case Based Approach", IEEE Press, Wiley, 2015
2. Walid A. Zgallai, "Biomedical Signal Processing and Artificial Intelligence in Healthcare", Academic Press, Elsevier, 2020
3. https://onlinecourses.nptel.ac.in/noc20_ee41/preview

References:

1. Willis J. Tompkins, "Biomedical Digital Signal Processing", PHI, 2004
2. D C Reddy, "Biomedical Signal Processing: Principles and Techniques", McGraw Hill, 2005
3. J G Webster, "Medical Instrumentation: Application and Design", Wiley, 2001
4. Katarzyna J. Blinowska, Jaroslaw Zygierewicz, "Practical Biomedical Signal Analysis Using MATLAB", CRC Press, 2021 (2nd Edition)
5. John G Proakis, Dimitris and G. Manolakis, "Digital Signal Processing Principles algorithms, applications", Pearson, 2014 (Fourth Edition)
6. https://www.coursera.org/lecture/mobile-health-monitoring-systems/problem-statement-9kkkD
7. https://www.coursera.org/lecture/mobile-health-monitoring-systems/noise-in-biomedical-signals-ksxUN

WIRELESS COMMUNICATIONS

ECE21RXXXX	Wireless Communications	L	T	P	X	C
		3	0	2	0	4
Pre-requisite	:	Analog and Digital Communication / Equivalent				
Course Category	:	Programme Elective				
Course Type	:	Integrated Course				

Course Description:

The course addresses the fundamentals of wireless communications and provides an overview of existing and emerging wireless communications networks. It covers radio propagation and fading models, fundamentals of cellular communications, multiple access technologies, and various wireless networks, including past and future generation networks. Simulation of wireless systems under different channel environments will be integral part of this course.

Course Objective:

- To study the characteristic of wireless channel
- To understand the design of a cellular system
- To study the various digital signalling techniques and multipath mitigation techniques
- To understand the concepts of Higher Generation Cellular Concepts

Course Outcomes:

At the end of the course, the student will be able to:

CO1 : Describe the basics of Wireless Communication Systems.

CO2 : Determine the capacity of wireless systems in fading environments and analyse the BER due to various fading.

CO3 : Characterize a wireless channel using mathematical concepts and the knowledge gained in Digital Communication

CO4 : Analyse the various multipath mitigation techniques for a wireless system under consideration.

CO5 : Explain the architecture for different modern wireless communication standards.

CO6 : Simulate a wireless system, evaluate its performance under different constraints in a laboratory and communicate the results inferred efficiently by oral/written reports.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	H					L						H		

CO2	H	H	L				L	L				L	H	M	
CO3	H	H	L				L					L	H	M	
CO4		H					L					H	H	M	
CO5		H					L						H		
CO6		L	H	H	H	L	L	H	M	H		M	H	M	L

Course Topics:

Unit 1: Wireless Communication Basics

Wireless Network system architecture, Functional blocks, Advantages and Challenges – Types of Wireless Services: Broadcast, Paging, Cordless, Trunking Radio, Cellular, Wi-Fi, Bluetooth, ZigBee, UWB, WLL, Ad-Hoc Networks and Sensor Networks – Requirements for the services

Unit 2: Wireless Communications and Diversity

Wireless Channel Modelling – Path loss, Shadowing, Fast fading – Rayleigh/Ricean Fading Channels – BER Performance – Antenna Diversity (MRC) – BER performance with diversity – types of diversity

Unit 3: Wireless Channel Modelling

WSSUS Channel Modelling – RMS Delay Spread – Doppler Fading – Jakes Model, Autocorrelation, Jakes Spectrum – Impact of Doppler Fading

Unit 4: CDMA, OFDM

Review of CDMA – Walsh codes, Variable tree OVSF – PN Sequences – Multipath diversity, RAKE receiver – CDMA receiver synchronization

Review of OFDM – Multicarrier modulation and cyclic prefix – Channel model and SNR performance, OFDM issues (PAPR) – Frequency offset

Unit 5: Wide-Area Wireless Networks (WANs), Other Wireless Systems

GSM – IS-136 – IS-95 – UMTS - CDMA 2000 – Space Time Codes – 4G, Long Term Evolution Technologies (LTE), LTE Advanced – IEEE 802.11 WLAN (Wi-Fi), WiMAX

Laboratory Experiments:

1 Simulate Basic Digital Baseband Communication through MATLAB

2 Simulation program for calculating Autocorrelations and Cross-Correlations of Binary Sequences using MATLAB

3 Analyse Grade-of-Service and Trunking using MATLAB

4 Simulation of BER performance of PSK and FSK schemes in Rayleigh frequency flat, slow fading channels using MATLAB

5 Simulation of BER performance of PSK scheme in Rayleigh frequency flat, slow fading channels with L^{th} order receive diversity using MATLAB

6 Simulation of BER performance of PSK scheme in Rayleigh frequency flat, slow fading channels with Transmit diversity using MATLAB

7 Simulation of BER performance of PSK scheme in 2x2 spatial multiplexing system in Rayleigh frequency flat, slow fading channels using MATLAB

8 Simulation of BER performance of OFDM system in Rayleigh frequency selective fading channels using MATLAB

9	LS and MMSE channel estimation in OFDM system using MATLAB
10	Apply Carrier frequency offset estimation in OFDM system using MATLAB
11	Apply Timing offset estimation in OFDM system using MATLAB
12	Build and analyse a short-range wireless communication system using MATLAB

Textbooks:

1. Aditya. K. Jegannatham, “Principles of Modern Wireless Communication Systems”, McGraw Hill India, 2016.
2. Andreas F. Molisch, “Wireless Communications”, Wiley US, 2012.
3. https://nptel.ac.in/courses/117/104/117104099/

References:

1. Upena Dalal and Manoj K. Shukla, “Wireless and Mobile Communication”, Oxford University Press India, 2016.
2. Mainak Chowdhury, Arumita Biswas, “Wireless Communication: Theory and Applications”, Cambridge University Press, 2017.
3. Andrea Goldsmith, “Wireless Communication”, Cambridge University Press, 2005.
4. Theodore S. Rappaport, “Wireless Communications: Principle and Practice”, Pearson India, 2010 (Second Edition).
5. https://onlinecourses.nptel.ac.in/noc19_ee49/preview
6. https://www.coursera.org/learn/wireless-communications

RFID TECHNOLOGIES FOR IOT

ECE21RXXXX	RFID Technologies for IoT	L	T	P	X	C
		3	0	2	0	4

Pre-requisite	**:**	Analog and Digital Communication / Equivalent
Course Category	**:**	Programme Elective
Course Type	**:**	Integrated Course

Course Description:

RFID systems with an emphasis on networking aspects and research challenges related to passive Ultra High Frequency (UHF) RFID systems. Various algorithms, protocols and design solutions that have been developed within the area, including most recent advances. Wide range of recognized problems in RFID industry.

Course Objective:

The objectives of this course are to provide in-depth understanding of the underlying concepts of RFID Technology for Internet of things, building blocks, domain specific IoTs, various RFID tag and protocols, standards associated with RF ID, Address the security and privacy in RF ID, Infrastructure Networking, IoT layers and Security

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Explain the basic components and RFID System, Classification, Frequency range applications of RFID systems
- **CO2 :** Analyse and characterise RFID tag and reader architectures
- **CO3 :** Analyse various protocols used in RFID systems
- **CO4 :** Design RF ID systems with an understanding of guidelines to be followed for Reader Infrastructure Networking
- **CO5 :** Use RFID in developing IoT applications
- **CO6 :** Design an IoT system applying RFID for the given scenario and able to evaluate the constraints of the system as an individual or as a team member in laboratory
- **CO7 :** Document the process carried in the laboratory which communicates the works effectively to the people

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	M	L											M		
CO2	L	L	M									L	M		L
CO3		L	M										M		
CO4		M	H					L	L	L			H		L
CO5		M	M				L						M		

CO6		L	L	M	H	L	L						M	L	L
CO7								H	L	L				M	L

Course Topics:

Unit 1: RFID Basics

Automatic ID systems and their comparison, RFID system components, Ideal RFID, Features of RFID, Practical RFID, Transponder Construction Formats - Classification of Commercially Available Products, Active and Passive Tags (Transponders), Information processing Transponders, Selection Criteria for RFID systems - RFID Operating principles: 1-Bit Transponder, Full- and Half- Duplex procedure, Sequential procedure, Near Field Communication (NFC), RFID Frequency ranges used.

Unit 2: RFID Tag Design, RFID Readers

RFID tag build and its environment, Tag Architecture systems, Standard CMOS Memory, Baseband of RFID Tag - Passive RFID operation, Passive RFID Reader design, Integrated Transceiver - RFID Transmitters and RFID Receivers - Digital-Analog Conversion and Signal Processing Packaging and Power, Dense Reader operations, RFID Middleware basics.

Unit 3: RFID Protocols

Aloha-Based Protocols, Tree-Based Anti-Collision Protocols - Requirements for RFID Protocols, Different Approaches Used in UHF Protocols - Description of Stochastic TTF Protocols, Comparison of protocols.

Unit 4: Reader Infrastructure Networking

Integrating RFID readers, EPC global standards - Interference problem in RFID Reader networks, Access mechanisms, Regulations, Standards and Algorithms - Reader Collision Avoidance, Coverage redundancy, Network Model, Redundant Reader Elimination Algorithms, RRE

Unit 5: RFID for IoT

Classification of RFID systems, Low power networking, Backscatter communication and RFID, Energy harvesting applications - IoT layers and Security (Qualitative analysis only), RFID as layer in Internet network - Case studies / Applications: Public Transport, Contactless Payment Systems, NFC applications, Access control

Laboratory Experiments:

1 Study of Basic Embedded C Program coding
2 Study of RFID Key, node MCU and Microcontroller
3 Study of NI My Tag and My Rio Trainer Kit
4 Data Integrity schemes like Parity Checking, CRC checking using MATLAB
5 Measuring real world data from NI My Tag and My Rio Trainer Kit
6 Design and Implement IoT based Door opening system using an RFID key.
7 Design and Implement RFID key attendance system
8 Multiple Access Procedures and Anti-collision using MATLAB
9 Design and implement RFID based lab equipment / library book tracking
10 Design and implementation of Vehicle speed monitoring using an RFID key

11 Design and implementation of IoT Based Vehicle starter using RFID key.
12 Implement the Security access control using a RFID Key.
13 Simulate a simple IoT medicine box via RFID key

Textbooks:

1. Klaus Finkenzeller, Dörte Müller, "Fundamentals and Applications in Contactless Smart Cards, Radio Frequency Identification and Near-Field Communication (RFID Handbook)", Wiley, 2010 (Third Edition).
2. Miodrag Bolic, David Simplot-Ryl, Ivan Stojmenovic, "RFID Systems: Research Trends and Challenges", Wiley, 2010.
3. https://nptel.ac.in/courses/108/108/108108123/

References:

1. Daniel M. Dobkin, "The RF in RFID: UHF RFID in Practice", Elsevier/Newness, U.S./India, 2012 (Second Edition).
2. Arshdeep Bahga, Vijay Madisetti, "Internet of Things – A hands-on approach", Universities Press, 2015.
3. Peter Waher, "Learning Internet of Things", Packt Publishing, 2015.
4. Amin Rida, Li Yang, Manos M. Tentzeris, Ar-tech House, "RFID-Enabled Sensor Design and Applications", Artech House, 2010.
5. Tom Igoe, "Getting Started with RFID: Identify Objects in the Physical World with Arduino (Make: Projects)", Make Community, LLC; 2012.
6. Jari-Pascal Curty, Michel Declercq, Catherine, Dehollain, Norbert Joehl, "Design and Optimization of Passive UHF RFID Systems", Springer, 2007.
7. https://nptel.ac.in/courses/108/108/108108098/

WIRELESS AD-HOC AND SENSOR NETWORKS

ECE21RXXXX	Wireless Ad-Hoc and Sensor Networks	L	T	P	X	C
		3	0	2	0	4
Pre-requisite	**:**	Wireless Communication / Equivalent				
Course Category	**:**	Programme Elective				
Course Type	**:**	Integrated Course				

Course Description:

The objective of this course is to introduce students with fundamental concepts, design issues and solutions to the issues – architectures and protocols- and the state-of-the –art research developments in ad hoc and sensor networks. This course will also provide students with an understanding of wireless Adhoc, and sensor networks enable them to recognize the wide range of applicability of these networks and provide them with an understanding of the major design issues including topics such as protocol mechanisms and resource constraints.

Course Objective:

- Learn Ad hoc network and Sensor Network fundamentals
- Understand the different routing protocols.
- Have an in-depth knowledge on sensor network architecture and design issues.
- Understand the transport layer and security issues possible in Ad hoc and Sensor networks
- Have an exposure to mote programming platforms and tools

Course Outcomes:

At the end of the course, the student will be able to:

CO1 : Explain the principles of ad hoc wireless and sensor networks

CO2 : Analyse various types of MANET Protocols.

CO3 : Explain the concepts of network architecture for WSN

CO4 : Identify a suitable routing algorithm based on the network and user requirement from the knowledge gained on MAC protocol issues.

CO5 : Design sensor network for indoor applications and analyse its performance by simulation in a laboratory

CO6 : Communicate effectively about the Wireless Adhoc Network by means of oral and written reports

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	L	H					L						H		
CO2	H	H	L				L	L				L	H	M	

CO3	H	H	L				L					L	H	M	
CO4		H					L					H	H	M	
CO5		L	H	H	H			H	H		L	M	H	M	
CO6								M	L	H				M	H

Course Topics:

Unit 1: Wireless Ad Hoc Networks Basics

Introduction to Wireless Networks and Ad-Hoc Networks, Different enabling technologies; Types and Examples of Ad-Hoc networks, their constraints and implementation challenges; Self-Organizing Behaviour of Wireless Ad-Hoc Networks, Cooperation in Mobile Ad-Hoc Networks, MANETs

MAC protocols in MANETs, MACA protocol, MACAW protocol, DBTMA protocol, MARCH protocol

Unit 2: MANET Protocols

Routing in MANETs, Proactive DSDV Routing Protocol, Proactive WRP, Proactive-Fisheye State Routing Protocol, Proactive-Optimised Link State Routing Protocol, Reactive-Dynamic Source Routing Protocol, Reactive Ad-Hoc on Demand Distance Vector Routing Protocol, Hybrid-Adaptive Distance Vector Routing Protocol, Hybrid ZRP and SHARP protocol, Multicasting and Multicasting protocols in MANETs (MOLSR and MAODV protocol), Mobility models for MANETs, Transport protocols for MANETs (Problem of TCP in MANET, different transport protocols, TCP with ELFN, Ad-Hoc TCP, TCP –Bus protocol, Basics of Opportunistic Networks and UAV networks.

Unit 3: WSN Architecture

Basics of Sensor Networks, Sensor node its components and applications, Types of Sensors, Sensor's Specification, Examples and Applications of Sensor Networks, Platforms for WSN: Hardware Platform, mica2, micaZ, telosB, cricket, Imote2, tmote, btnode, -motes, Sensor node software (Operating System): tiny0S, MANTIS, Contiki, and Ret0S. Programming tools: C, nesC, WSN Coverage and Placement, Single node architecture, WSN Network Architecture: typical network architectures data relaying and aggregation strategies, Topology management in WSN (Topology Discovery Algorithm, Sleep Cycle Management Algorithm, Clustering Algorithms) Mobile WSNs

Unit 4: WSN Routing Protocols

Medium Access Control and SMAC in Wireless Networks, Routing in WSN: Unit Disk Graph Model, Multi-hop communication, Data-Centric Routing, Greedy Position based Localised Routing, Data Aggregation with example and Clustering Algorithms, Sensor Protocols for Information via Negotiation, Low-Energy Adaptive Clustering Hierarchy, Power-Efficient Gathering in Sensor Information Systems, Geographical Routing, Location Discovery, Congestion and Flow control, Congestion Detection and Avoidance protocol, Pump Slowly Fetch Quickly protocol, Rate-Control Reliable Transport Protocol, QoS, Security and Attacks in WSN

Unit 5: Recent WSN Tends, WSN Design and Real-Life Deployments

Underwater Sensor Networks: Basics, Types, Architecture, Topology management, Routing, Design Principles for WSN, Gateway Concepts Need for gateway, WSN to Internet Communication and vice-versa, WSN for improved Water Management for Irrigated Crops, WSN for Agriculture Intrusion Detection

Laboratory Experiments:

1 Introduction of Wireless sensor network applications and its simulation Using NS2
2 Simulating a MANET using NS2
3 Multiple WSN running simultaneously – evaluate the performance of WSN Using NS2
4 Write TCL script for sensor nodes with different parameters Using NS2
5 Study other wireless sensor network simulators
6 Study of WSN components using simulation software / kit.
7 Generate Tcl script for TCP and CBR traffic in WSN nodes Using NS2
8 Simulate Data routing, single and multi-hop Using NS2
9 Simulating a Wireless Sensor Network Routing (Modern protocol) Using NS2
10 Implementation of Congestion Avoidance (Modern) protocol Using NS2
11 Calculating Wireless range Using NS2
12 Design and simulate a small WSN system.

Textbooks:

1. C. Siva Ram Murthy and B.S. Manoj, “Ad Hoc Wireless Networks – Architectures and Protocols”, Pearson, 2004.
2. Holger Karl, Andreas Willig, “Protocol and Architecture for Wireless Sensor Networks”, Wiley, 2006.
3. https://nptel.ac.in/courses/106/105/106105160/

References:

1. Waltenegus Dargie, Christian Poellabauer, “Fundamentals of Wireless Sensor Networks Theory and Practice”, Wiley, 2011.
2. Kazem Sohraby, Daniel Minoli, Taieb Znati, “Wireless Sensor Networks: Technology, Protocols, and Applications”, Wiley, 2007.
3. Jun Zheng, Abbas Jamalipour, “Wireless Sensor Networks: A Networking Perspective”, Wiley, 2009.
4. Carlos de Morais Cordeiro, Dharma Prakash Agrawal, " Ad Hoc and Sensor Networks Theory and Applications”, World Scientific Press, 2011 (Second Edition).

OPTICAL NETWORKS

ECE21RXXXX	Optical Networks	L	T	P	X	C
		3	0	2	0	4

Pre-requisite	**:**	Analog and Digital Communication / equivalent
Course Category	**:**	Programme Elective
Course Type	**:**	Integrated Course

Course Description:

This course presents the state-of-the-art in the field of "Optical communication networks" which encompasses traditional networks operating on optical fibre as well as the next-generation networks such as wavelength division multiplexed (WDM) and optical time division multiplexed (OTDM) networks. The course will provide students with a fundamental understanding of optical network design.

Course Objective:

Make Students to Familiarize students with the optical network evolution and introduce the main elements and components of the all-optical networking Solution

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Describe physical properties of optical network.
- **CO2 :** Explain the various components involved in optical network.
- **CO3 :** Describe about the SONET/SDH and architecture of optical network.
- **CO4 :** Discuss the elements of WDM network design
- **CO5 :** Identify the function of photonic packet switching.
- **CO6 :** Simulate the optical network for given requirements and document the same through report, as a team/individual following the ethics and norms.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	L										L	H		
CO2	H	L										L	H		
CO3	H	H										M	H	L	
CO4	L	L										M	L	L	
CO5	L	L										L	L	L	L
CO6	L		H	M	H	L	L	H	H	H		H	M	H	H

Course Topics:

Unit 1: Optical Network

Optical network, optical layer, Optical Packet Switching, Transmission Basics: Wavelengths, Frequencies, and Channel Spacing wavelength Standards, Optical Power and Loss, Network Evolution: Early Days—Multimode fibre, Single-Mode fibre, Optical Amplifiers and WDM, Beyond Transmission Links to Networks

Unit 2: Components

Components: couplers, isolators, circulators, Multiplexers, filters, amplifiers, Switches, and wavelength converters.

Unit 3: SONET and SDH Network

Integration of TDM signals, Layers, Framing, Transport overhead, Alarms, Multiplexing, Network elements, Topologies, Protection architectures, Ring architectures, Network Management

Unit 4: WDM Network Design

Cost Trade-Offs: A Detailed Ring Network Example, LTD and RWA Problems, Lightpath Topology Design, Routing and Wavelength Assignment, Wavelength Conversion, Dimensioning Wavelength-Routing Networks, Statistical Dimensioning Models, First-Passage Model, Blocking Model, Maximum Load Dimensioning Models, Offline Lightpath Requests, Online RWA in Rings

Unit 5: Photonic Packet Switching

Optical Time Division Multiplexing, Bit Interleaving, Packet Interleaving, Optical AND Gates, Synchronization, Tuneable Delays, Optical Phase Lock Loop, Buffering, Output Buffering, Input Buffering, Recirculation Buffering, Using Wavelengths for Contention Resolution, Deflection Routing, Testbeds: KEOPS, NTT's Optical Packet Switches, BT Labs Testbeds, Princeton University Testbed, AON, CORD

Laboratory Experiments:

1 Transmit and receive the signal using fibre optic cable using optical transmitter and Receiver kit
2 Measure the light gathering capacity of the fibre
3 Measure the number of modes propagating in the multimode fibre
4 Power launching and testing of optic power loss between two plastic fibres in ST connectors using Optical transmitter and Receiver kit.
5 Multiplex two modulated signals using Optisystem and observe the various parameters of multiplexer.
6 Design optical fibre amplifiers and fibre lasers using Optisystem
7 Analyse the Time multiplexing capability of fibre using Optical Transmitter and Receiver kit.
8 Design an Ideal multiplexer using Optisystem
9 Analyse the Wavelength Division multiplexing capability of fibre using Optisystem
10 Analyse the different models of Wavelength Routing network
11 Multiplex different signal using WDM by using virtual lab
12 Test the integrity of optical fibre using OTDR

Textbooks:

1. Rajiv Ramaswami and Kumar Sivarajan, “Optical Networks: A practical perspective”, Elsevier / Morgan Kaufmann, 2009 (Third Edition).
2. Debasish Datta, “Optical Networks”, Oxford University Press, 2021.
3. https://nptel.ac.in/courses/117/101/117101002/

References:

1. Hussein T. Mouftab and Pin-Han Ho, “Optical Networks: Architecture and Survivability”, Kluwer Academic Publishers / Elsevier, 2003.
2. Biswanath Mukherjee, Ioannis Tomkos, Massimo Tornatore, Peter Winzer, Yongli Zhao (Editors), “Handbook of Optical Networks”, Springer, 2020.
3. Joseph C Patios, “Fiber Optical Communications”, Prentice Hall, 2004 (Fifth Edition).
4. G. P. Agrawal, “Nonlinear Fiber Optics”, Academic Press, 2012 (Fifth Edition).
5. Uyless N. Black, Front Royal, Virginia, “Optical Networks, Third Generation Transport Systems”, Prentice Hall, 2008.
6. C. Siva Ram Murthy and Mohan Guruswamy, “WDM Optical Networks - Concepts Design and Algorithms”, Prentice Hall, 2020.
7. https://www.tutorialspoint.com/optical_networks/index.htm

NATURAL LANGUAGE PROCESSING

ECE21RXXXX	Natural Language Processing	L	T	P	X	C
		3	0	2	0	4

Pre-requisite	**:**	Mathematics III / equivalent
Course Category	**:**	Programme Elective
Course Type	**:**	Integrated Course

Course Description:

Natural language processing (NLP) is the subfield of artificial intelligence that focuses on automatically understanding and generating natural language (e.g., Arabic, Telugu, Tamil, Hindi, Spanish, or English). It is crucial to many everyday applications ...if you have searched for something online or engaged in dialogue with one of your devices today, you have made use of many different NLP technologies already. This class will introduce the foundations and most popular applications of natural language processing. Topics covered will include text pre-processing, part-of-speech tagging, syntactic and dependency parsing, language modelling, word embeddings, text classification, and dialogue systems, among others.

Course Objective:

Students who complete this course will gain a foundational understanding in natural language processing methods and strategies. They will also learn how to evaluate the strengths and weaknesses of various NLP technologies and frameworks as they gain practical experience in the NLP toolkits available

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Explain the fundamentals of Natural Language Processing and the foundations of core Natural Language Processing algorithms
- **CO2 :** Apply concepts in Mathematics specifically probability and statistics and understand machine learning techniques used in NLP
- **CO3 :** Design and implement issues in various NLP applications
- **CO4 :** Analyse text data generated from a range of real-world applications
- **CO5 :** Analyse designing procedures for natural language resource annotation and use NLP methods to analyse sentiment of a text document
- **CO6 :** Apply programming skills for NLP applications
- **CO7 :** Work as part of a team and as individual effectively in applying NLPK as a tool and communicate the result in oral/written report.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	L		H	L									M	
CO2		H	H		L	M						H	H		

CO3			H	H	M							H		H	
CO4			M		H		L					H			M
CO5					H									M	
CO6					H	H				M		L	H	M	
CO7								H	H	M				M	M

Course Topics:

Unit 1: Natural Language Processing Basics

Regular Expressions, Words, Language modelling with N-grams, The Hidden Markov Model, Likelihood Computation: The Forward Algorithm, decoding: The Viterbi Algorithm, Part-of-Speech Tagging, HMM Part-of-Speech Tagging, Feed-Forward Neural Networks, Training Neural Nets, Neural Language Models.

Unit 2: Statistical Parsing

CKY Parsing: A Dynamic Programming Approach, Probabilistic Context-Free Grammars, Probabilistic CKY Parsing of PCFGs, Ways to Learn PCFG Rule Probabilities, Problems with PCFGs, Improving PCFGs by Splitting Non-Terminals, Probabilistic Lexicalized CFGs, Probabilistic CCG Parsing, Evaluating Parsers, Human Parsing Dependency Relations

Unit 3: Vector Semantics

Words and Vectors Weighing terms: Pointwise Mutual Information (PMI) Measuring similarity: the cosine, Syntax to define a word's context, Evaluating Vector Models, Semantics with Dense Vectors, Dense Vectors via SVD, Embeddings from prediction: Skip-gram and CBOW, Properties of embeddings, Brown Clustering

Unit 4: Word Sense Disambiguation

Methodological Preliminaries- Supervised and unsupervised learning, Pseudowords, Upper and lower bounds on performance, Supervised Disambiguation - Bayesian classification, an information-theoretic approach, Dictionary-Based Disambiguation, Disambiguation based on sense definitions, Thesaurus-based disambiguation, Disambiguation based on translations in a second-language corpus, One sense per discourse, one sense per collocation, Unsupervised Disambiguation

Unit 5: Lexical Semantics

WordNet and Available Sentiment Lexicons, Semi-supervised induction of sentiment lexicons, Supervised learning of word sentiment, Using Lexicons for Sentiment Recognition, Speech Recognition, Clinical documentation, NLP for Healthcare summaries, Chatbot

Laboratory Experiments:

1, Study of Natural Language processing toolkit
2, POS Tagging using Hidden Markov Model
3, POS Tagging using Viterbi Decoding
4, Text classification with an FNN-Setup input
5, Text classification with an FNN-Create the text Encoder and train model
6, Text classification with an FNN-Stack two or more LSTM layers
7, Estimate bigrams from a given corpus and calculate probability of a sentence

8, NLP analysis of Restaurant reviews
9, Word Embedding- Representing text as numbers
10, Word Embedding- Encode each word with unique number
11, Word Embedding – Text pre-processing and visualize the embedding
12, Generate skip gram from one sentence
13, Negative sampling for one skip gram

Textbooks:

1. Daniel Jurafsky and James H Martin, "Speech and Language Processing", Pearson US, 2018 (Second Edition) / 2021 (Third Edition).
2. Nitin Hardeniya, Jacob Perkins, Deepti Chopra, Nisheeth Joshi, Iti Mathur, "Natural Language Processing: Python and NLTK", Packt Publishing, 2016.
3. https://nptel.ac.in/courses/106/105/106105158/

References:

1. Jacob Eisenstein, "Introduction to Natural Language Processing", MIT Press, 2019.
2. Steven Bird, Ewan Klein, and Edward Loper, "Natural Language Processing with Python", O'Reilly, 2009.
3. Aman Kedia, Mayank Rasu, "Hands on Python Natural Language Processing", Packt Publishing, 2020.
4. Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta, and Harshit Surana, "Practical Natural Language Processing: A Comprehensive Guide to Building Real-World NLP Systems", O'Reilly, 2020.
5. Yoav Goldberg, "A Primer on Neural Network Models for Natural Language Processing", Morgan and Claypool, 2016.
6. Rajesh Arumugam, Rajalingappaa Shanmugamani, "Hands-On Natural Language Processing with Python", Packt Publishing, 2016.
7. https://nptel.ac.in/courses/106/106/106106211/
8. https://www.edx.org/learn/natural-language-processing
9. https://www.coursera.org/learn/language-processing

PROGRAM ELECTIVES – SPECIAL ADDITIONAL ELECTIVES FOR HONOURS STUDENTS

PROCESS AND DEVICE SIMULATION

ECE21RXXXX	Process and Device Simulation	L	T	P	X	C
		3	0	2	0	4
Pre-requisite	:	Electronic Devices / Equivalent				
Course Category	:	Programme (Honours') Elective				
Course Type	:	Integrated Course				

Course Description:

The course explains the physics and principals involved in silicon processing and device characterization.

Course Objective:

To learn the fundamentals of VLSI processes and devices; To model the VLSI processes and devices with TCAD; To better understand the modern technology development and transistor design and optimization through process variation.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Explain basics related to semiconductor modelling and various semiconductor industries.
- **CO2 :** Describe TCAD and its different methodologies.
- **CO3 :** Design and simulate the processing and characteristics of required devices.
- **CO4 :** Analyse the various models used in SDevice feature and apply it for evaluating device characteristics of a PN junction diode.
- **CO5 :** Develop practical skills in state-of-the-art TCAD tools through MOSFET devices and analysing its threshold and IV characteristics. Apply them for the given problems/experiments following the ethics and safety norms.

Mapping of Course Outcomes:

CO /	PO												PSO		
PO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	H	M											H	M	
CO2	H	M	H	M	M								H	H	L
CO3		H	M	M	L									H	
CO4				M	H	L	M	H	L		L			H	L
CO5								M	M	M		L		M	M

Course Topics:

Unit 1: Basics

Physical Modelling: Forms of physical modelling: analytical modelling vs. numerical modelling – Design sequence with computation: Process simulation – Device simulation – Compact Modelling or Parameter Extraction and Circuit Simulation

Semiconductor Companies: ASIC and FPGA business – Electron design automation – Intellectual property – IC Development flow: Moore's Law, Wafer preparation, design stage, fabrication and test stage, reliability, and qualification stage. Case study on fabrication flow of fundamental.

Unit 2: Origin and Purpose of TCAD

TCAD: What and Why – History – TCAD: 2D vs 3D – Compact model vs. TCAD, TCAD for nanoelectronics – TCAD in Fabrication technology development – Device simulation sequence – TCAD Design flow – Sentaurus Structure editor – Sentaurus Device. Case study for SDE and SDevice for fundamental devices.

Unit 3: Process Simulation

Basic semiconductor processing steps: Meshing, Oxide formation, Mask formation. Physical Models: Diffusion Model – Oxidation Model – Impact Ionization model – Etch model – post-processing and parameter extraction – Drain current versus drain voltage simulation – Drain current versus gate voltage simulation. Process simulation of fundamental PN diodes.

Unit 4: Device Simulation

Numerical solution methods – Non-linear iteration – initial guess requirement – Semiconductor Device Analysis – Field-Effect Structures – Fermi statistics – Dopant Ionization – Carrier mobility - Carrier Transport: Diffusion current – Einstein relation – Continuity equation and solution – PN Junction Diode: Contact definitions – Device simulation – Junction capacitance – Simulation data – Case study of PN diode and its IV characteristics.

Unit 5: MOSFET Characteristics

Basic Operation of MOSFET – Threshold Voltage – IV characteristics – MOS Capacitor – Device models for circuit simulation – Threshold voltage characterisation – IV characterization – Statistical characterization – Case study of MOSFET IV characteristics and threshold voltage.

X- Component Topics:

1 Study of numerical modelling of a transistor and its device performances. Extraction of device parameters
2 Study of fabrication flow for semiconductors and its quality measures.
3 Study of 2D and 3D structure using SDE and SDevice feature
4 Use process simulation for using several Sprocess steps like oxide and mask formation for a PN junction
5 Simulate the various physical models and understand their functionality (Process Simulation)
6 Simulate the ID-VD and ID-VG characteristics from SProcess for the simulated device.
7 Design fundamental semiconductor devices like PN junction diodes and FETs with SDE and SDevice.
8 Calculate the equilibrium case and carrier transport in BJTs and PN junctions.

9 Calculate IV characteristics of a PN diode using SDevice.
10 Extraction of MOSFET device parameters related to output characteristics, transfer characteristics.
11 Visualize MOS transistor operation in terms of doping, potential, field, carrier, current distributions;
12 Observe and relate device performance parameters to process variations;

Textbooks:

1. Simon Li and Yue Fu, "3D TCAD Simulation for Semiconductor Processes, Devices and Optoelectronics", Springer, 2012.
2. Chandan Kumar Sarkar, "Technology Computer Aided Design: Simulation for VLSI MOSFET", CRC Press, 2013.
3. https://onlinecourses.nptel.ac.in/noc21_ee80/preview

References:

1. G.A. Armstrong and C. K. Maiti, "Technology Computer Aided Design for Si, SiGe and GaAs Integrated Circuits", IET, 2007.
2. Gouranga Bose, "IC Fabrication Technology", McGraw Hill India, 2011.
3. Daniel Nenni and Minas Staff, "Fabless: Transformation of the Semiconductor Industry", CreateSpace, 2014.
4. https://www.coursera.org/learn/vlsi-cad-logic

PATTERN RECOGNITION AND COMPUTER VISION

ECE21RXXXX	Pattern Recognition and Computer Vision	L	T	P	X	C
		3	0	2	0	4
Pre-requisite	**:**	Digital Signal and Image processing / Equivalent				
Course Category	**:**	Programme (Honours') Elective				
Course Type	**:**	Integrated Course				

Course Description:

This course aims to provide students with a detail knowledge on how system can recognition an object through various features by training and testing process.

Course Objective:

The objectives of this course are.

To study about the various patterns of the object has been identified using various features extraction methods.

To study about the various classifying methods to train and test the object.

To study the performance of the recognition of object.

Course Outcomes:

At the end of the course, the student will be able to:

CO1 : Apply the statistical methods of pattern recognition process

CO2 : Determine basic feature extraction methods in computer vision

CO3 : Analyse the performance of various recognition methods

CO4 : Apply pattern recognition technique to Iris, fingerprint and Palmprint

CO5 : Develop the pattern recognition technique for video analysis (MPEG).

CO6 : Work as part of a team and as individual effectively in designing the communication systems following the norms and ethics in practice

CO7 : Communicate the technical information related to designed communication systems by means of oral and written reports

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M			L							L	H		
CO2	M	H			L							L	H	M	
CO3	H	H			L		M					M	H	M	
CO4		H	L		M	L	M					H	M	M	M
CO5			M	M	M	L						M	H	M	M
CO6								H	H		L				
CO7								L	M	H				L	

Course Topics:

Unit 1: Basic methods in Pattern- Recognition

Statistical Pattern Recognition, Hidden Markov Models for Spatial -temporal pattern- Local invariant features, Kernal based formalization of Minimum Error Pattern.

Unit 2: Basic methods in Computer Vision

Case Study based reasoning for Image analysis and Interpretation, Multiple image geometry- Digital Distance Transforms in 2D and 3D, Skeletonization in 3D discrete binary images, Local binary patterns.

Unit 3: Recognition Applications

Document analysis and understanding-Character Recognition, Extraction of words from handwritten documents, Automated detection of Masses in Mammograms, Independent Component analysis.

Unit 4: Human Identification

Palm Print Recognition, Iris recognition, Fingerprint Recognition.

Unit 5: System and Technology

Tracking and classifying moving objects using cameras, Content based Video analysis for knowledge discovery, Case study: Musical Style Recognition

Laboratory Experiments:

1 Compute likelihood of the class for a given sample, from the density functions and related information with Bayes optimal classifier using Matlab
2 Compute parameter estimation to be evaluated and compared with HMM parameter using Matlab
3 Compute error pattern analysis using Kernal based function with Matlab
4 Analyse 2D and 3D distance transforms using MATLAB
5 Compute texture descriptor with LBP operator using Matlab
6 Compute basic document recognition using Matlab
7 Compute multivariate signal analysis with ICA using Matlab
8 ICA based Palm Print Recognition using Matlab
9 LDA based Iris recognition using Matlab
10 LBP based Fingerprint Recognition using Matlab
11 Detection of objects from MPEG using Matlab
12 HMM based voice recognition using Matlab

Textbooks:

1. C H Chen, P S P Wang, “Handbook of Pattern Recognition and Computer Vision”, World Scientific Publisher, 2016 (Third Edition).
2. E.R. Davies Octavia, Camps Matthew Turk, “Advanced Methods and Deep Learning in Computer Vision”, Elsevier: Academic press, 2020.
3. https://nptel.ac.in/courses/117/105/117105101/

References:

1. Mei Chen, “Computer vision for Microscopy Image Analysis”, Elsevier: Academic press, 2020.
2. Xavier Alameda-Pineda Elisa Ricci Nicu Sebe, “Multimodal Behaviour Analysis”, Elsevier: Academic press, 2018.
3. Massimo Tistarelli, Christophe Champod, “Handbook of Biometrics for Forensic Science”, Springer, 2017.
4. https://ocw.mit.edu/courses/brain-and-cognitive-sciences/9-913-pattern-recognition-for-machine-vision-fall-2004/

ELECTRONICS FOR AUTONOMOUS NAVIGATION SYSTEMS

ECE21RXXXX	Electronics for Autonomous Navigation Systems	L	T	P	X	C
		2	0	0	3	3
Pre-requisite	:	Signals and Systems / Equivalent				
Course Category	:	Programme (Honours') Elective				
Course Type	:	Theory				

Course Description:

This course covers fundamentals of navigation, sensor technologies for autonomous navigation system, Trajectory prediction, mapping and planning for indoor navigation, Inertial Navigation System (INS), Gyroscope Navigation sensors, short range navigation, long range navigation, RADAR Navigation and GPS based navigation system

Course Objective:

To learn and understand the concepts of various navigational systems for drones, UAV, Autonomous vehicle, Aircraft, Autonomous Robot and Aerospace Vehicles

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Compare and select the sensor technologies for autonomous navigation of robots and drones
- **CO2 :** Interpret the path planning of navigation for indoor navigational robots/drones
- **CO3 :** Explain the working of inertial navigation system and Gyro-sensors
- **CO4 :** Explain the concepts of short-range, long-range radio navigation system and RADAR systems
- **CO5 :** Describe the concepts of GPS based Navigational system

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	L		L								M	H	L	
CO2	H	L		L								L	H		L
CO3	H	L	M									L	H		
CO4	H			L								L	M		
CO5	H	L		L								M	H		L

Course Topics:

Unit 1: Fundamentals of Navigation and Inertial Sensors

Definition of navigation, guidance, and control-General principles of conventional navigation systems-Geometric Concepts of navigation Reference frames- Euler angles,

Direction cosines and quaternions - Coordinate transformations - Comparison of transformation methods.

Sensor technologies for Autonomous Navigation: Gyro meter, Accelerometer, Radar, Sonar, LIDAR, Infrared, GPS, touch sensors, proximity sensors, sound sensors, vision sensors, Sensor Fusion

Unit 2: Modelling of Navigation

Degree of autonomy, components of mobile robot, Behaviour modelling, trajectory prediction, localization and mapping methods, and path planning in the presence of obstacles, Feature based Simultaneous Localisation and Mapping (SLAM), Indoor Navigation.

Unit 3: Inertial Navigation system

Inertial navigation-Block diagram representation-Inertial platforms Stable platforms-Gimbelled INS and Strapdown INS and their mechanization-IMU. Navigation equations-Schuler principle and mechanization-Gyro compassing for initial alignment.

Gyroscopes- Principle of operation-Precession- Nutation- Gimbal lock Gimbal Flip-Gyro transfer function-Rate Gyro-Integrating gyro. Constructional details and operation of floated rate integrating gyro Dynamically tuned gyro-Ring laser gyro-Fibre optic gyro-Gyro performance parameters.

Unit 4: Radio Navigation systems

Radio navigation systems-short range navigation systems-Basics of VOR, TACAN, DME-Long range navigation-Basics of OMEGA, LORAN-Instrument Landing System. Introduction to radars-Block schematic diagram and Principle of operation-Radar Equation-Range and frequencies- Application of radars- Types of radar-Pulse Doppler Radar, MTI, Tracking Radar.

Unit 5: Satellite Navigation System

Satellite navigation systems-Global Positioning Systems (GPS) - Global Navigation of Satellite Systems (GNSS)- GPS aided navigation-GAGAN

X- Component Topics: / Laboratory Experiments:

1 Tutorial on Euler angles, Direction cosines and quaternions
2 Tutorial on Coordinate transformation and Transformation methods using MATLAB
3 Tutorial on sensors Modelling: Calibration and simulation for IMU, GPS, and range sensors
4 Tutorial on trajectory generation and Trajectory Prediction using MATLAB Navigation Toolbox
5 Tutorial: 2-D and 3-D simultaneous localization and mapping using MATLAB Navigation Toolbox.
6 Tutorial on Highway Trajectory Planning Using Frenet Reference Path using MATLAB-Navigation Toolbox
7 Survey on Inertial Navigation system (in terms of sensor Technology, Localization, mapping, and planning Methods)
8 Tutorial on Navigation Range measurement
9 Tutorials on RADAR duty cycle, Power, Doppler shift, and Range calculations

10 Tutorials on GPS Orienting using Android smartphone with Google Map or Google Earth Applications

11 Path Planning and Navigation for Autonomous Robots using MATLAB with Simulink, Navigation, Robotics system, and ROS toolboxes

Textbooks:

1. Amitava Bose, Thomas Kurian, K. N. Bhat, "Fundamentals of Navigation and Inertial Sensors", Prentice Hall, 2014.
2. Paul D. Groves, "Principles of GNSS, Inertial, and Multisensor Integrated Navigation Systems", Artech House, 2013 (Second Edition).
3. https://nptel.ac.in/courses/101/108/101108056/

References:

1. Sebastian Thrun, Wolfram Burgard, and Dieter Fox, "Probabilistic Robotics", MIT Press, 2005.
2. Anthony Lawrence, "Modern Inertial Technology", Springer, 2001 (Second Edition).
3. M.I. Skolnik, "Introduction to Radar Systems", McGraw Hill, 2007 (Third Edition).
4. Myron Kayton, Walter R. Fried, "Avionics Navigation System", Wiley, 2013 (Third Edition).
5. David Titteron and John Weston, "Strapdown Inertial Navigation Technology", IEEE Radar, Sonar, Navigation and Avionics Series, 2005 (Second Edition).
6. Ching-Fang Lin, "Modern Navigation, Guidance and Control Processing", Prentice Hall, 1991.
7. https://pressbooks.bccampus.ca/geoglabs2020/chapter/lab-14-gps-orienting/

VIRTUAL REALITY AND AUGMENTED REALITY

ECE21RXXXX	Virtual Reality and Augmented Reality	L	T	P	X	C
		2	0	0	3	3
Pre-requisite	**:**	Electronic Devices and Basic Programming / Equivalent				
Course Category	**:**	Programme (Honours') Elective				
Course Type	**:**	Theory				

Course Description:

The course helps in the students enhancing his knowledge in the domain of Virtual and Augmented Reality, through understanding them by their similarities and differences, and their applications.

Course Objective:

To provide the theoretical knowledge about Virtual and Augmented Reality technologies and the fundamental concepts involved in building and displaying virtual worlds.

Course Outcomes:

At the end of the course, the student will be able to:

CO1 **:** Demonstrate an understanding of the underlying enabling technologies of Virtual Reality systems

CO2 **:** Explain the operation of input and output devices for Virtual Reality

CO3 **:** Demonstrate an understanding of the underlying enabling technologies of Augmented Reality systems

CO4 **:** Describe the operation of hardware and software programming with respect to augmented reality systems

CO5 **:** Carry a literature survey on the recent happenings with respect to VR and AR and communicate efficiently the findings in oral/written report.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	L					M					M	H	M	
CO2	M	H					M					M	H	M	
CO3	H	L					M					M	H	M	
CO4	M	H					M					M	H	M	
CO5		H				H	H	M	L	H			H	M	

Course Topics:

Unit 1: Virtual Reality Fundamentals

Elements of Virtual Reality Experience - VR Becomes an Industry - Components of a VR system - VR and Society - Visual Rendering System – Aural Rendering System -Haptic Rendering System

Unit 2: VR – Input and Output Devices

Visual Displays: Properties, Monitor Based, Projection Based, Head Based, See-through head based, Handheld VR Displays - Aural Displays: Properties, Head based and Stationary aural devices - Haptic Displays: Human haptic system, Tactile type, force type

Unit 3: Augmented Reality Fundamentals

Components and Platforms of AR - Ingredients of AR - AR Tools - Working of AR

Unit 4: AR Hardware and Software

Sensors - AR Contact Lenses – Processors - Manipulation – Navigation

Unit 5: VR and AR Applications

Mobile AR, Advantages and Disadvantages - Architecture of mobile AR - Trends and Research in VR - Future of AR and VR

X- Component Topics: / Laboratory Experiments:

1	Comparison of Virtual Reality, Augmented Reality, Telepresence and Cyberspace - Evolution of VR
2	Visual representation in VR, Aural representation in VR, Haptic representation in VR
3	Creating a VR application
4	Position trackers: Parameters, Mechanical tracker, magnetic tracker, ultrasonic tracker, optical tracker, video-metric tracker, hybrid inertial tracker, neural tracker
5	Gesture Interfaces: Pinch Glove, 5DT Data Glove, The Didjig Glove, Cyber Glove
6	Navigation and Manipulation Interfaces: Tracker based interfaces, tracker ball, 3D Probes
7	The Differences Between Augmented Reality and Virtual Reality - Challenges with AR
8	Creating visual content – creating audio content – creating content for other senses
9	Reality applications and interaction in projected AR environments
10	Reality systems
11	Displays
12	AR applications
13	Case studies: Magic books, Magic mirrors, Magic windows and doors, Magic lens, Navigation assistance
14	Medical applications and educational applications of VR

Textbooks:

1. William R. Sherman, Alan B. Craig, “Understanding Virtual Reality: Interface, Application, and Design”, Morgan Kaufmann Publishers (Elsevier), 2017 (Second Edition).
2. Dieter Schmalstieg, Tobias Hollerer, “Augmented Reality: Principles and Practice”, Pearson, (Addison Wesley Professional), 2016 (Second Edition).
3. https://www.coursera.org/learn/ar

References:

1. Tom Dieck, “Augmented Reality and Virtual Reality: The Power of AR and VR for Business”, Springer, 2019.
2. Tony Parisi, “Learning Virtual Reality: Developing Immersive Experiences and Applications for Desktop, Web and Mobile”, O’Reilly, 2016 (Second Edition).
3. Grigore C. Burdea, Philippe Coiffet, “Virtual Reality Technology”, Wiley, 2003 (Second Edition).
4. Greg Kipper, Joseph Rampolla, “Augmented Reality: An Emerging Technologies Guide to AR”, Syngress (Elsevier), 2013.
5. Paul Mealy, Virtual and Augmented Reality for Dummies, Wiley, 2018.
6. Nawaz Mohamudally, “State of the Art Virtual Reality and Augmented Reality: Knowhow”, IntechOpen, 2018.

SATELLITE COMMUNICATION

ECE21RXXX	Satellite Communication	L	T	P	X	C
		2	0	0	3	3
Pre-requisite	:	Analog and Digital Communication / Equivalent				
Course Category	:	Programme (Honours') Elective				
Course Type	:	Theory				

Course Description

The goal of the course is to introduce students to the fundamentals of satellite communication. To provide them with a sound understanding of how a satellite communication system successfully transfers information from one earth station to another.

Course Objective:

The student will be made to:

- Understand the basics of satellite orbits.
- Understand the budgeting for satellite links.
- Analyse the various methods of satellite access.
- Understand the applications of satellites.

Course Outcomes:

At the end of the course, the student will be able to:

CO1 : Describe the basic theories and principles in satellite communication systems to analyse the satellite orbits and subsystem.

CO2 : Describe the satellite link design and budget for satellite links.

CO3 : Compute modulation and coding scheme in satellite communication systems

CO4 : Enumerate the application of Geostationary satellites.

CO5 : Elaborate the theories related to non-Geostationary satellite services.

Mapping of Course Outcomes:

CO /	PO												PSO		
PO	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	H											H		
CO2	H	H	M			L	L	L				L	H		L
CO3	H	H	H			L	L					L	H		L
CO4	H	H					L					L	H		L
CO5	H	H					L					L	H		L

Course Topics

Unit 1: Introductions to Satellite Communication

History of satellite communications - General structure of satellite communication - Band Spectrum (L, S, C, Ku, K, Ka, V, and W bands) - Importance of 6/4 GHz and 14/11 GHz systems - Satellite applications - Satellite orbits: Orbital mechanics, Circular Orbits, Types of Earth Orbits, Performance characteristics of different altitude satellites, Elliptical Orbits, Kepler's Laws, Apsis and periapsis, Equations (2D, Difference) and Numerical Techniques for Computing Orbits, Look angle determination - Orbital Perturbations - Orbital Elements - Orbit Determination - Orbital Shift - Space Launch Vehicles and Rockets - Attitude and Orbit Control System - Telemetry, Tracking, Command and Monitoring - Communication subsystems - Satellite antennas.

Unit 2: Satellite Link Design

Basic transmission theory - System noise temperature and G/T Ratio - Downlink design - Ku-Band GEO Satellite Systems - Uplink design - Example System Design for Specific Performance.

Unit 3: Communication Techniques

Digital Transmission - Zero ISI Transmission - Probability of Error - Digital Transmission of Analog Signals - Error Control - Multiple Access Techniques: TDMA, FDMA, CDMA, DAMA; On-board processing, Implementation of error detection on satellite - Packet Radio systems and Protocols - Satellite-networks, Intersatellite Communications.

Unit 4: Communication Satellite Services

Communication Satellite Applications - Frequency Bands, Payloads, Satellite Vs. Terrestrial Networks, Satellite Telephony, Satellite Television, Satellite radio, Satellite Internet - Home Satellite TV - Digital DBS TV: DVB, DVB-S and DVB-S2 standards - DBS TV System Design - DBS-TV Link Budget for DVB-S and DVB-S2 Receivers - Master Control Station and Uplink - Satellite Internet using GSO and NGSO - NGSO: Orbital considerations, coverage and frequency considerations, NGSO Constellation Designs, and System design example.

Unit 5: Satellite Navigation and Specialized Services

Global Positioning Satellite System (GPS): GPS Position Location Principles, GPS Receivers and Codes, GPS Receiver Operation - Remote Sensing Satellites: Classification of remote sensing systems, orbits, Payloads, Types of images: Image Classification, Interpretation, Applications - Weather Forecasting Satellites: Fundamentals, Images, Orbits, Payloads.

X- Component Topics:

1 Tutorial:
Indian Satellite History, ISRO and its activities,
Radius for Geosynchronous Earth (Circular Orbit)

2 Tutorial:
Hohmann transfer orbit
Gravitational slingshot
Molniya orbit

3 Tutorial on calculation of escape velocity, orbits using MATLAB

4 Tutorial on Link Budget for a practical satellite application like TV broadcasting

5 Tutorial on Digital Modulation Methods
6 Tutorial on Spread Spectrum Techniques
7 Tutorial on Quantifying Attenuation and Depolarization
8 Tutorial on Predicting Rain Attenuation
9 Tutorial on error rate calculation in DBS-TV system design.
10 Tutorial on power and loss calculation in Satellite Radio Broadcasting.
11 Tutorial on VSAT systems
12 Indian Activities in Satellite Communication: GSO, NGSO and Small Satellites of India
13 Tutorial on Small Earth Stations in India

Textbooks:

1. Timothy Pratt, Charles Bostian, Jeremy Allnutt, "Satellite Communications", Wiley India, 2020 (3rd Edition - An Indian Adaptation).
2. R. N. Mutagi, "Satellite Communication: Principles and Applications", Oxford University Press, India, 2016.
3. https://nptel.ac.in/noc/courses/noc17/SEM2/noc17-ec14/

References:

1. Dr. Anil K. Maini, Varsha Agarwal, "Satellite Communications", Wiley India, 2010 (As per AICTE).
2. P. Banerjee, "Satellite Communication", Prentice Hall, 2017.
3. Kenneth Y. Jo, "Satellite Communications Network Design and Analysis", Artech, 2011.
4. K. N. Raja Rao, "Satellite Communication: Concepts and Applications", Prentice Hall, 2013 (Second Edition).
5. Michael Olorunfunmi Kolawole, "Satellite Communication Engineering", CRC Press, 2017 (Second Edition).
6. https://www.coursera.org/learn/satellite-communications

DISPLAY SYSTEMS

ECE21RXXXX	Display Systems	L	T	P	X	C
		2	0	0	3	3
Pre-requisite	**:**	Electronic Devices / Equivalent				
Course Category	**:**	Programme (Honour's) elective				
Course Type	**:**	Theory				

Course Description:

This course deals with display and projection systems elements and working features. It also deals with advancement related to current display and projection systems and its recent technology.

Course Objective:

To expose the students to the basics of the display systems and to illustrate the current design practices.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Explain the fundamentals of display systems.
- **CO2 :** Describe the various transmissive and reflective type displays working principles.
- **CO3 :** Analyse the different emissive and projection display workings.
- **CO4 :** Analyse the technology behind the near eye displays.
- **CO5 :** Describe the working principles of 3D displays.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M										L	H		L
CO2	H	M											H		
CO3	H	M	M			L	L					L	H		L
CO4	H	M	M									L	H		L
CO5	H	M										L	H		L

Course Topics:

Unit 1: Display Basics

The Human Visual System, Colorimetry, Depth Perception, Motion Pictures - Fundamental Measures of Displays, Colour, and Intensity Production - Electronics of Displays, Various Display Assembly Technologies

Unit 2: Transmissive Displays, Reflective Displays

Transmissive Displays: LCD, TN LCD, STN LCD, MVA LCD, IPS LCD, LED-LCD, Driving LC Displays, Ferroelectric LCD (FLC) - Reflective Displays (Bi-Sable LCD, DMD and Driving DMD E-Ink, Electrowetting Displays,)- Reflective Displays (Electrofludic Displays, iMOD Displays, Electronic Paper Tiled Displays, HDR Displays,

Unit 3: Emissive Displays, Projection Displays

Emissive Displays (CRT, OLED, AMOLED, QLED, Field Emission Displays,) - Projection Displays (Projector Optics, Projection Lenses and Lamps, OLED Projectors, LCD Projectors, DLP and GLV Projectors, Holographic Projector)- Projector Screens, Rear Projections, Laser Projectors.

Unit 4: Near Eye Displays

Display Technologies for Near-Eye Displays, Near-Eye Displays Examples, Combiner Mirrors, Optics Design- On-Axis NED, LASER Near Eye Displays, Smart NED, Light Field NED, Holographic Image Generation for NED, Advanced HOE Designs- Contact Lens Displays, Contact Lens Displays, Adaptive Displays and Eye tracking.

Unit 5: 3-D Displays

Basic considerations, Spatial Spectroscopic Displays - Autostereoscopic Displays: Parallax Displays and Volumetric Displays- Light Field Displays, Computer-Generated Holograms

X- Component Topics:

1 Tutorial on Display – Scanning methods
2 Tutorial on various TV systems like PAL, SECAM, NTSC
3 Tutorial on Character LCD
4 Tutorial on Segmented Displays
5 Tutorial on Touch Screen Displays
6 Tutorial on Types of Mobile Displays
7 Tutorial on Selecting displays for Mobile devices
8 Tutorial on building projection based Tiled displays
9 Tutorial on displays for virtual reality
10 Tutorial on hologram displays
11 Tutorial on holographic principle and optics
12 Tutorial on Plasma displays

Textbooks:

1. Rolf R. Hainich, Oliver Bimber, “Displays Fundamentals and Applications”, CRC Press, 2017 (Second Edition).
2. Janglin Chen, Wayne Cranton, Mark Fihn (Editors), “Handbook of Visual Display Technology”, Springer, 2016(Second Edition).
3. https://nptel.ac.in/courses/106/106/106106090/

References:

1. R G Gupta, Television Engineering and Video Systems, McGraw Hill, India, 2011 (Second Edition).

2. A Veeralakshmi and R Srivel, “Television and Video Engineering”, Ane Books, 2013.
3. E.H. Stupp, M. S. Brennesholtz, “Projection Displays”, Wiley, 2008 (Second Edition).
4. Joseph A. Castellano, “Handbook of Display Technology”, Elsevier, 1992.
5. https://www.coursera.org/learn/displays
6. https://www.edx.org/course/optical-materials-and-devices

FLEXIBLE ELECTRONICS

ECE21RXXXX	Flexible Electronics	L	T	P	X	C
		2	0	0	3	3

Pre-requisite	**:**	Electronic Devices / Equivalent
Course Category	**:**	Programme (Honours') Elective
Course Type	**:**	Theory

Course Description:

The course will provide a survey of the materials and processes use to fabricate flexible electronic devices. Organic and inorganic semiconductors, dielectrics, and metals will be presented along with the advantages and disadvantages for integrating disparate materials onto novel platforms such as plastic, paper, and textiles. An overview of different processing techniques will be presented to describe the many conventional and emerging technologies.

Course Objective:

The aim of the course is theoretical familiarisation with specific rules of design and manufacture of flexible electronic devices and circuits as well as technological processes.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Develop basic concepts and understanding of thin-film electronic materials and device processing.
- **CO2 :** Identify the terminology, equipment, and design methodology used in the fabrication, and characterisation of FE systems
- **CO3 :** Recognize and discuss the societal and economical significance of FE systems applications, including benefits and potential risks.
- **CO4 :** Design layouts, exemplary circuits, and flexible electronics devices with the gained knowledge on flexible electronic materials and technology.
- **CO5 :** Explain basic concepts for integration of thin-film devices on flexible platforms and the advantages and disadvantages of emerging technology used for the heterogeneous integration of disparate materials.

Mapping of Course Outcomes:

CO /	PO												PSO		
PO	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H						M					H	H		L
CO2	H	L					M					H	H	L	L
CO3	H						M					H	H	L	L
CO4	H	L					M					H	H	M	L
CO5	H											H	H		L

Course Topics:

Unit 1: Flexible Electronics Basics

Introduction to Flexible and Printed Electronics and their Materials Systems – Background and history – emerging technologies – general applications – Review of Semiconductors and Circuit Elements – Carrier transport, doping, band structure – thin-film electronic devices.

Unit 2: Flexible Devices Fabrication and Materials

Thin-film Deposition and Processing Methods for Flexible Devices, CVD, ECVD, PVD – etching – photolithography – low-temperature process integration – Materials for Flexible and Printed Electronics: Nanowire and nanoparticle synthesis, transition metal oxides, amorphous thin films, polymeric semiconductors, paper-based electronics, textile substrates, barrier materials

Unit 3: Thin Film Transistors

Thin Film Transistors device structure and performance: I-V characteristics – Mechanics of Thin-films and Flexible Thin-film Transistors: thin-film mechanics models, neutral plane, conformal electronics, mechanical modelling.

Unit 4: Patterning Process, Interfaces

Solution-based Patterning Processes: Ink-jet printing – gravure – imprint lithography – spray pyrolysis – surface energy effects – multilayer patterning Contacts and Interfaces to Organic and Inorganic Electronic Devices: Schottky contacts – defects – carrier recombination – effect of applied mechanical strain

Unit 5: Applications and Economics

Flexible Electronics Applications: Displays, sensor arrays, memory devices, MEMS, lab-on-a-chip, and photovoltaics – Introduction to Cost Models and Economics: Overview of display industry cost models, cost advantages and disadvantages for printed electronics, scaling of large-area flexible systems, cost of goods sold for display applications

X- Component Topics:

1 Tutorial on various applications of Flexible Electronics as Case studies
2 Simulation of Thin film electronic devices using TCAD.
3 Simulation of processing for thin-film devices using TCAD
4 Simulation of various thin film material properties using TCAD
5 Modelling a thin film transistor using TCAD.
6 Analyse the characteristics of thin-film transistor using TCAD.
7 Tutorial on VLSI Technology for Flexible and Micro devices.
8 Tutorial on Organic and Inorganic Electronic Devices characteristics.
9 Tutorial on interfacing of devices using TCAD.
10 Modelling a MEMS using software like TCAD.
11 Study of commercially available thin film materials and the products in terms of technology and economics.
12 Calculation of economics for any of the flexible electronic applications.

Textbooks:

1. Wong, William S., Salleo, Alberto (Editors), “Flexible Electronics: Materials and Application”, Springer, 2009
2. Guozhen Shen, Zhiyong Fan (Editor), “Flexible Electronics: From Materials to Devices”, World Scientific, 2016

References:

1. Takao Someya (Editor), Stretchable Electronics, Wiley, 2013

WIRELESS MIMO TECHNOLOGY

ECE21RXXXX	Wireless MIMO Technology	L	T	P	X	C
		3	0	2	0	4

Pre-requisite	**:**	Analog and Digital Communication / Equivalent
Course Category	**:**	Programme (Honours') Elective
Course Type	**:**	Integrated Course

Course Description:

This course focuses on MIMO communication system, which includes MIMO system model, various channel modelling, channel coding and detection techniques and MIMO Applications

Course Objective:

To learn and understand the concepts of MIMO systems for 5G Communication, satellite communication and RADAR Applications

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Explain the MIMO communication system and MIMO channel modelling.
- **CO2 :** Apply the channel coding and detection techniques for MIMO communication System
- **CO3 :** Develop the modelling for MIMO system and channel using MATLAB
- **CO4 :** Analyse the Advance Mobile communication systems
- **CO5 :** Recognize ethical and professional responsibilities in modelling, conducting experiments and computing the parameters of MIMO Communication System and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- **CO6 :** Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, in modelling MIMO Communication System

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	H	M	M	H		H						H	L	
CO2	H	M											H		
CO3	H	M											H		
CO4	H	M											H		
CO5	H	M											H		

Course Topics:

Unit 1: MIMO Wireless Communication System

MIMO channel and signal model, fundamental trade-off, Diversity-multiplexing trade-off, transmit diversity schemes, advantages and applications of MIMO systems, MIMO transceiver design, MIMO in wireless networks, MIMO in wireless standards. Capacity limits of MIMO systems: Mutual information and Shannon capacity, Single-user MIMO, Multi-user MIMO, Multi-cell MIMO, MIMO for ad hoc networks

Unit 2: MIMO Channel Models and Channel Capacity

Fading Channel Models: Uncorrelated - fully correlated - separately correlated - keyhole MIMO fading models, parallel decomposition of MIMO channel, Power allocation in MIMO: Uniform - adaptive - near optimal power allocation. Capacity for deterministic MIMO Channels, Capacity of random MIMO channels-MIMO (Unity Channel Matrix, Identity Channel Matrix), Capacity of independent identically distributed channels.

Unit 3: Space–Time Coding for Wireless Communications

Space–time coding principles, Applications, Advantages, code design criteria, Alamouti space-time codes, SER analysis of Alamouti space-time code over fading channels, Space-time block codes, Space-time trellis codes, Performance analysis of Spacetime codes over separately correlated MIMO channel, Space-time turbo codes, BLAST Architectures: VBLAST – HBLAST – SCBLAST - DBLAST.

Unit 4: MIMO Detection Techniques

Maximum Likelihood, Zero Forcing, Minimum Mean Square Error, Zero Forcing Equalization with Successive Interference Cancellation, Minimum Mean Square Error Successive Interference Cancellation, Lattice Reduction based detection. Multi-user receiver design: Multiple-access MIMO systems, Iterative space–time multi-user detection, Multi-user detection in space–time coded systems.

Unit 5: Advances in MIMO System

Spatial modulation, MIMO based cooperative communication and cognitive radio, multiuser MIMO, cognitive-femtocells, and large MIMO systems for 5G wireless, MIMO Applications in RADAR, Satellite Communication, and Wi-Fi.

Laboratory Experiments:

1. Study of Communication Toolboxes and Simulink functions in MATLAB
2. Build a QPSK transmitter and Receiver using MATLAB Simulink.
3. Develop an Uncorrelated MIMO wireless Channel model using MATLAB Simulink and the characteristics
4. Develop a correlated MIMO wireless Channel Model using MATLAB Simulink and the characteristics
5. Build a 2x2 MIMO system with Simulink (transmitter, channel, and receiver) and conduct simulations. Assume two SISO receivers.
6. Performance analysis of 2 x 2 MIMO system using different modulation techniques with ML detection algorithm in correlated and uncorrelated channel conditions
7. Performance analysis of 2 x 2 MIMO system using different modulation techniques with VBLAST detection algorithm

8 Performance analysis of 2 x 2 MIMO system using different space time coding techniques with ML detection algorithm

9 Performance analysis of Multi-user MIMO system using BPSK modulation technique with SIC and V-Blast detection algorithm

Textbooks:

1. Rakhesh Singh Kshetrimayum, "Fundamentals of MIMO Wireless Communications", Cambridge University Press, 2017.
2. A. Chockalingam, B. Sundar Rajan, "Large MIMO Systems", Cambridge University Press, 2014.
3. http://nptel.ac.in/courses/117/105/117105132/

References:

1. A. Goldsmith, "Wireless Communications", Cambridge University Press, 2005 (Second Edition).
2. B. Kumbhani and R. S. Kshetrimayum, "MIMO Wireless Communications over Generalized Fading Channels", CRC Press, 2017.
3. Thomas L. Marzetta, Erik G. Larsson, Hong Yang, Hien Quoc Ngo, "Fundamentals of Massive MIMO", Cambridge University Press, 2016.
4. E. S. Gopi, "Digital Signal Processing for Wireless Communication using MATLAB", Springer, 2016 (Third Edition).
5. Mischa Dohler, Jose F. Monserrat Afif Osseiran, "5G Mobile and Wireless Communication Technology", Cambridge University Press, 2016.
6. Tim Brown, Persefoni Kyritsi, Elizabeth De Carvalho, "Practical Guide to MIMO Radio Channel: with MATLAB Examples", Wiley, 2012.
7. https://www.mathworks.com/help/comm/ug/introduction-to-mimo-systems.html
8. https://www.edx.org/course/4g-network-essentials

BIOCHIPS: TECHNOLOGY AND APPLICATIONS

ECE21RXXXX	Biochips: Technology and Applications	L	T	P	X	C
		2	0	0	3	3
Pre-requisite	**:**	Biology for engineers / Biology at School level				
Course Category	**:**	Programme (Honours') Elective				
Course Type	**:**	Theory				

Course Description:

The increasing need for integration, sensitivity, and reliability in biological measurements is leading the research to delve into Bio-sensing microsystems and Biochips. Integration in Biosystems aims at implementing valuable monitoring techniques as replacement to conventional time-consuming and often sophisticated approaches, which can be performed only by high-specialized technicians in a laboratory environment. The course covers bio-sensing microsystems and Biochips giving insights on the design flow methodology in Biosystems, adopted fabrication techniques, bio-transducing principles, and signal acquisition systems

Course Objective:

To impart knowledge on the basics of bio sensing units and implantable devices
To impart knowledge on the components and types of biochips
To make students learn about fabrication techniques of biochips

Course Outcomes:

At the end of the course, the student will be able to:

CO1 : Elaborate the biological molecules and biological materials
CO2 : Explain principles of various biosensors.
CO3 : Analyse the architecture of various biochip types
CO4 : Describe the technology of Biochips
CO5 : Illustrate the various real-time applications of Biochips

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H											L	H		L
CO2	H	L				L	L					M	H		M
CO3	H	L				L	L					M	H		M
CO4	H												H		
CO5	H	L	L			L	L					M	H	L	L

Course Topics:

Unit 1: Biology and Electronics

Biological materials: analogy between semiconductor and biological materials, water, and electrolyte solutions - Biological molecules: Proteins, Nucleic acids, Phospholipids - Cell membrane; Eucaryotic cell

Unit 2: Biosensors

Different Types of Bioreceptors - Antibody Bioreceptor, Enzyme Bioreceptors, Nucleic Acid Bioreceptors, Cellular Bioreceptors, Biomimetic Receptors - Types of Transducers: Optical Technique, Electrochemical Techniques, Mass-sensitive Techniques - Biosensor Applications: Agricultural, food safety, food processing: state of the field, market potential, unique design, criteria, and needs- Types of Biochips: DNA Chip, Protein Chip, Enzyme Chip, Lab-on-a-Chip

Unit 3: Biochip Architecture and Types

Biochip Architecture, Biochip Transponder, Active and Passive transponder, Biochip Antenna, Capsule, Microcomputer of Biochips, Reader- Integrated biochip system, Advantages and Limitations of biochip technology

Unit 4: Biochip Fabrication

Fabrication techniques: Microarray: DNA array, Protein array, Electronic and Electrochemical array Microfluidic: Continuous flow array, Digital flow array, Bio-Mems Fabrication - Architectural Optimizations for Digital Microfluidic Biochips.

Unit 5: Biochip Applications

Applications of Biochip - Molecular analysis application of Biochip: Protein, Hybridization, Immunological, Nucleotides, Biomarkers, Food Safety; - Diagnostics Applications of Biochip: Cancer, Gene Diagnostics, Blood Clot; - Drug discovery; - non-biological applications of Biochip: Temperature Control, Organic Semiconductors

X- Component Topics:

1 Tutorial on Review of Cell Biology
2 Tutorial on Review of DNA, RNA
3 Tutorial on Biosensors with Interfacing circuits in the CMOS IBS.
4 Tutorial on Design an Electrochemical Biosensor and Optical Biosensor
5 Case Study: Microchip used in a computer
6 Tutorial on Biochip reader with dynamic holographic excitation and hyperspectral fluorescence detection
7 Case study: A biochip reader using super critical angle fluorescence
8 Tutorial on MEMS fabrication and Biosensors
9 Tutorial on Biochip as a Glucose detector
10 Tutorial on Biochip as an oxygen sensor
11 Tutorial on Biochip as a BP sensor
12 Tutorial on Biochip Platforms for DNA Diagnostics

Textbooks:

1. Xueji Zhang Huangxian Ju Joseph Wang (Editors), “Electrochemical Sensors, Biosensors and their Biomedical Applications”, Elsevier, 2007

2. Inamuddin Raju Khan Ali Mohammad Abdullah Asiri, “Advanced Biosensors for Health Care Applications”, Elsevier, 2019
3. https://onlinecourses.nptel.ac.in/noc20_ee14/preview

References:

1. Gabi Nindl Waite, Lee Waite, “Applied Cell and Molecular Biology for Engineers”, McGraw Hill India, 2016
2. Nam-Trung Nguyen, Steven T. Wereley, Seyed Ali Mousavi Shaegh, “Fundamentals and Applications of Microfluidics”, Artech, 2019
3. Jing Cheng and Larry J. Kricka (Editors), “Biochip Technology”, Taylor and Francis, 2001
4. Krishnendu Chakrabarty, Tao Xu, “Digital Microfluidic Biochips Design Automation and Optimization”, Taylor and Francis, 2010

FPGA BASED SYSTEM DESIGN

ECE21RXXX	FPGA Based System Design	L	T	P	X	C
		3	0	2	0	4

Pre-requisite	**:**	Digital Circuits and Systems Design
Course Category	**:**	Programme (Honours') Elective
Course Type	**:**	Integrated Course

Course Description

The course gives an insight in designing complex digital systems using integrated circuit cells as building blocks and employing hierarchical design methods. Emphasis is given on digital design using VHDL and FPGA architectures.

Course Objective:

To learn the fundamentals of FPGA architecture; To familiarise with optimised VLSI circuits design using FPGA; Design circuits using VHDL.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Describe the architecture of FPGAs.
- **CO2 :** Analyse digital systems with FPGA programming.
- **CO3 :** Write VHDL programs for optimised system design using FPGA.
- **CO4 :** Interface basic devices to FPGA in designing digital systems.
- **CO5 :** Analyse FPGA Large Scale Systems.
- **CO6 :** Use modern electronic design automation (EDA) tools and FPGA to simulate and synthesis digital circuit as part of a team and as individual following the safety procedures and ethics.
- **CO7 :** Document the results inferred from Laboratory Experiments in oral and written reports.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M											H		
CO2			M	M	H		H							H	L
CO3			L	H	H	L	H							H	
CO4			L	M	H	L	H							H	L
CO5								H	H		L			M	M
CO6								M	H	H		L		M	M
CO7								M	H	H		L		M	M

Course Topics

Unit 1: FPGA Architecture

FPGA evolution - FPGA design techniques - Design constraints using FPGAs - Digital Design and FPGA – FPGA Fabrics: FPGA Architectures, SRAM Based FPGAs - Permanently Programmed FPGAs – FPGA Chip I/O – Circuit Design and architecture of FPGA Fabrics.

Unit 2: FPGA Programming

VHDL essentials: Entity: model interface, Architecture, Process, Variable types and operators, Decisions and Loops - Hierarchical design – Debugging models: Assertions – Basic data types, Simulation and Test benches - Libraries – Synthesis – Place and route – VHDL issues for FPGA design.

Unit 3: FPGA System Design

Design using VHDL: Flip-flops, Registers, Counters - Serial to Parallel conversion, Parallel to Serial conversion – ALU function - Decoders, Multiplexers, Encoders, Demultiplexers – Binary multiplier. FPGA-Based System Level Design of Adders Circuit – A case study approach for ALU.

Unit 4: FPGA Interfacing methods

Serial Communication: RS232 – Camera Link Interface - ADC interface – High-speed Data Converter Using Parallel and Serial Interface - PS/2 Mouse Interface – PS/2 Keyboard Interface, VGA Interface.

Unit 5: FPGA Large Scale Systems

Introduction – Busses: Protocols and Specifications, Logic Design for Busses - Platform FPGAs: Platform FPGA Architectures, Serial I/O - Multi-FPGA Systems: Interconnecting Multiple FPGAs, Multi-FPGA Partitioning - Novel Architectures: Machines Built from FPGAs, Alternative FPGA Fabrics - Applications: FPGA Programming: Traffic Light Controller, Flash Alarm.

Laboratory Experiments:

1 Study of Altera DE1 or Spartan 3 or Virtex 5 FPGA boards and FPGA software.
2 Design a simple digital circuit using VHDL and implement on FPGA.
3 Design and implement ripple carry adder using FPGA
4 Design and implement carry look ahead adder using FPGA
5 Design and implement shift and add multiplier using FPGA.
6 Design and implement pipelined serial adder to add/subtract 8-bit number of sizes, 12 bits each in 2's complement using FPGA.
7 Design and implement traffic light controller as FSM using FPGA as a real time application of counter.
8 Design and implement arithmetic and logic unit using FPGA as a real time application of ALU and MUX.
9 Design and implement FSM sequence detector using FPGA
10 Design and implement keyboard and mouse interface using FPGA.
11 Design and implement vending machine controller using FPGA.

12 Design and implement 24 hours real time clock using FPGA's master crystal clock with HH:MM display on FPGA's 7-Segment LED display using FPGA

Textbooks:

1. Peter Wilson, "Design Recipes for FPGAs: Using Verilog and VHDL", Elsevier (Newnes), 2015
(Second Edition).
2. Wayne Wolf, "FPGA-Based System Design", Pearson U.S./Prentice Hall India, 2010 (Second Edition).
3. https://nptel.ac.in/courses/117/108/117108040/#

References:

1. Seetharaman Ramachandran, "Digital VLSI Systems Design: A Design Manual for Implementation of Projects on FPGAs and ASICs using Verilog", Springer, 2007.
2. Gina R. Smith, "FPGAs 101: Everything You Need to Know to Get Started", Elsevier/Newnes, 2010.
3. Cem Unsalan and Bora Tar, "Digital System Design with FPGA: Implementation Using Verilog and VHDL", McGraw Hill India, 2017.
4. Valery Sklyarov, Iouliia Skliarova, Alexander Barkalov, Larysa Titarenko, "Synthesis and Optimization of FPGA-Based Systems", Springer, 2014.
5. Lingkan Gong, Oliver Diessel, "Functional Verification of Dynamically Reconfigurable FPGA-based Systems", Springer, 2015.

BRAIN COMPUTER INTERFACING

ECE21RXXXX	Brain Computer Interfacing	L	T	P	X	C
		2	0	0	3	3

Pre-requisite	**:**	Digital Signal and Image Processing / Equivalent
Course Category	**:**	Programme (Honours') Elective
Course Type	**:**	Theory

Course Description:

An introduction of how our brain works will also be discussed. Followed by which the course discusses on definitions, the history, benefits, and drawbacks of BCI. The later part focuses on BCI components, types, medical and non-medical BCI applications, BCI technologies, and the current and future status of BCI.

Course Objective:

To make the student understand the Advantages and Applications of BCI, through which the concepts of working of the brain, Algorithms, Sensors used are being discussed.

Course Outcomes:

At the end of the course, the student will be able to:

CO1 : Explain the BCI Signals of interest to know the working of Human Brain.
CO2 : Discuss different algorithms available in BCI.
CO3 : Identify the latest sensors used for the purpose of BCI.
CO4 : Explain the methods used in capturing BCI Signals.
CO5 : Identify the applications of BCI in various domains

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	L												L		
CO2	M			L								L	M		L
CO3	M	L	L	L								L	M		L
CO4	M			L								L	M		L
CO5	M	M	H	L	L							M	M	L	M

Course Topics:

Unit 1: Basics of Brain Computer Interfacing BCI

Neuroimaging-Based Approaches in the BCI - Brain Anatomy - Brain Computer Interface Types - Types of BCI Signals - Components of Interest

Unit 2: Translational Algorithms

Heart of a Brain - Computer Interface - BCI Development Process - Types of BCI

Unit 3: Sensors for BCI

EEG electrodes - Latest generation sensors - Magnetoencephalography

Unit 4: Non-invasive BCIs

Functional Magnetic Resonance Imaging-Based BCIs - Functional Near Infrared and Optical BCIs - Sensory Restoration - Motor Restoration

Unit 5: BCI Applications and Ethics

Rehabilitation- Restoring Communication with Menus, Cursors, and Spellers - Sensory Restoration - Motor Restoration - Cognitive Restoration - Brain-Controlled Wheelchairs - Estimating Cognitive Load

X- Component Topics:

1	Control Signals in BCI Systems
2	Monitoring Brain Activity Using EEG
3	Brain Computer Interface Applications - BCI Trends
4	Sources of Information for a BCI
5	Computational Techniques
6	Various Non-Invasive recording techniques for BCI
7	Comparison of MRI and FMRI functionalities
8	BCI Evaluation
9	3D graphics, virtual reality, and motion-onset visual evoked potentials in neurogaming
10	Error Potentials in BCIs
11	Brain- Controlled Wheelchairs
12	Lie Detection and Applications in Law
13	Security, Identification, and Authentication application

Textbooks:

1. Fabien Lotte, Laurent Bougrain, Maureen Clerc, “Brain-Computer Interfaces 1: Methods and Perspectives”, Wiley, 2016.
2. Rajesh P. N. Rao, “Brain-Computer Interfacing: An Introduction”, Cambridge University Press, 2013.

References:

1. Anton Nijholt, Chang S. Nam, Fabien Lotte, “Brain–Computer Interfaces Handbook: Technological and Theoretical Advances”, CRC Press, 2018.
2. José del R. Millán, Nick F. Ramsey, “Brain-Computer Interfaces”, Elsevier, 2020.
3. Ahmad Taher Azar, “Brain-Computer Interfaces: Current Trends and Applications”, Springer, 2014.
4. Caterina Cinel, Davide Valeriani, Riccardo Poli, “Brain-Computer Interfaces for Human Augmentation”, MDPI AG, 2019.
5. Pablo Diez, “Smart Wheelchairs and Brain-computer Interfaces: Mobile Assistive Technologies”, Elsevier, 2018.

EMBEDDED SOFTWARE AND HARDWARE ARCHITECTURE

ECE21RXXX	Embedded Software and Hardware Architecture	L	T	P	X	C
		3	0	2	0	4
Pre-requisite	:	Microcontrollers and Interfacing Techniques / Equivalent				
Course Category	:	Programme (Honours') Elective				
Course Type	:	Integrated Course				

Course Description

This course introduces the design of embedded and ubiquitous computing systems including their hardware and software architectures, design methodologies and tools, and communication protocols. The course features a series of integrated assignments using state-of-the-art embedded hardware platforms, embedded software design tools, and real-time operating systems.

Course Objective:

- To explain the definition, characteristics, challenges of Embedded Systems design. Also, highlight the principles of processor technologies, IC technologies, general purpose processors and processor selection strategies.
- To impart the fundamental knowhow of I/O interfacing, serial communication protocol and buses.
- To introduce the concepts and features of Real-time operating systems, task scheduling, memory management, resource synchronization and inter-task communication.
- To introduce various programming tools, modelling and simulation packages to program, design, simulate and real time Embedded Systems

Course Outcomes:

At the end of the course, the student will be able to:

CO1 : Review the characteristics, applications, examples, design challenges related to Embedded Systems

CO2 : Identify microprocessor/ microcontroller for a particular application based on the knowledge gained on microprocessors.

CO3 : Discuss the interfacing of basic peripherals to microcontrollers in designing a system for the given specifications

CO4 : Differentiate the pros and cons of various serial communication and bus interfaces

CO5 : Differentiate the features of RTOS and GPOS and understand the concepts inter-process communication and real time task scheduling

CO6 : Design and implement algorithms for realistic, sustainable embedded systems in a laboratory as a team and as individual following the safety procedures, ethics.

CO7 : Propose, carry out, orally present, and write laboratory findings with observations and interpretations.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1		M			M								M	L	
CO2	L	L		M	H		L					L	L	H	
CO3			M		M	L							M	L	
CO4		H		H									H	M	
CO5		H		L									H	L	
CO6			M	M	H	L		L	M	L	L	L	L	M	L
CO7				M	L		M	H	H	H		L		L	L

Course Topics

Unit 1: Embedded Hardware Building Blocks, Embedded Processors

The Embedded Board and the von Neumann Model, Powering the Hardware, Basic Hardware Materials,

ISA Architecture Models, Internal Processor Design, Processor Performance, Board

Unit 2: Embedded Processors: I/O, Bus and Memory

Memory: Memory Management of External Memory, Board Memory and performance, Board I/O (Input/Output), Managing Data: Serial vs. Parallel I/O, Interfacing the I/O Components, I/O and Performance, Board Buses Arbitration and Timing, Integrating the Bus with Other Board Components, Bus Performance

Unit 3: Embedded Software Development Process and Tools

Introduction to Embedded Software Development process and Tools, Host and Target machines, linking and Locating software, Getting Embedded Software into the Target system, Issues in Hardware-Software Design and Co-Design, Testing on Host Machine, Simulators

Unit 4: Embedded Software: Device Drivers and Embedded OS

Device Drivers for Interrupt-Handling: Memory Device Drivers, On-board Bus Device Drivers, Board I/O Driver Examples, Multitasking and Process Management, Memory Management, OS Standards Example: POSIX (Portable Operating System Interface), OS Performance Guidelines, OSes, and Board Support Packages (BSPs), RTOS

Unit 5: Design Examples and Case Studies of Program Modelling and Programming with RTOS

Case study of coding for sending application layer byte stream on TCP/IP Network using RTOS Vx works, Case Study of Digital Camera hardware and Software Architecture, Case Study of an Embedded Systems for a smart card, Case study of a mobile phone software for Key inputs

Laboratory Experiments:

1 Memory copy operation for getting familiar with IDE.

2	Design and execute a branched program; perform different conditional subprogram calls and to perform memory copy.
3	Interface EPROM and interrupt.
4	Input Capture (Ultrasonic Distance Sensor) in Assembly
5	Input Capture (Ultrasonic Distance Sensor) in C
6	Switch the processor mode and watch the behaviour of the registers in different modes, through ARM instructions.
7	Write a program to communicate between PC and Controller using RS232 interface at 9600-baud rate.
8	Write a program to communicate between two controllers using SPI (Serial Peripheral Interface).
9	Write a program to generate variable duty cycle of Pulse Width Modulation (PWM) using ARM board.
10	Write a program to use of Timers 0/1 in Timer Mode and generate delay and use this delay to blink LED. Also calculate the delay.
11	Write a program to erase a particular memory block and re-write with some other LED pattern code. Use switches for selecting different LED patterns.
12	Analyse the interrupt performance characteristics of ARM and FPGA

Textbooks:

1. K.C. Wang, "Embedded and Real-Time Operating Systems", Springer, 2017.
2. Xiaocong Fan, "Real-Time Embedded Systems: Design Principles and Engineering Practices", Elsevier, 2015.
3. https://www.coursera.org/learn/embedded-software-hardware

References:

1. Raj Kamal, "Embedded Systems Architecture, Programming and Design", McGraw-Hill, India, 2011.
2. Tammy Noergaard, "Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmers", Elsevier, 2012.
3. Sriram V Iyer Pankaj Gupta, "Embedded Realtime Systems Programming", McGraw-Hill, India, 2003.
4. Gajski, "Specification and Design of Embedded Systems", Pearson, 2007.
5. Alexander G. Dean, "Embedded Systems Fundamentals with ARM Cortex-M Based Microcontrollers: A Practical Approach", ARM Education Media, 2017.
6. https://www.coursera.org/lecture/embedded-software-hardware/1-memory-access-and-manipulation-introduction-4VDDD

7. https://www.coursera.org/lecture/embedded-software-hardware/1-architecture-software-interface-pNVIO

UNIVERSITY ELECTIVES

GPS FUNDAMENTALS

ECE21RXXX	GPS Fundamentals	L	T	P	X	C
		2	0	0	3	3

Pre-requisite	**:**	Basic Electronics
Course Category	**:**	University Elective
Course Type	**:**	Theory

Course Description

The aim of this course is to introduce the Global Positioning System and to demonstrate its application to various aspects of Engineering Sciences.

Course Objective:

To familiarise the students with Global Navigation satellite communication systems operation.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Describe the basic parameters of Global Navigation Satellite System.
- **CO2 :** Describe GPS in terms of constellation and services.
- **CO3 :** Calculate user position from GPS pseudo range data using the knowledge gained on GPS signal, codes, and biases.
- **CO4 :** Enumerate the knowledge on various Global Navigation Satellite Systems.
- **CO5 :** Elaborate the practical applications of GPS.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M					L					L	H		
CO2	H	H	M				L							H	M
CO3	H	H	H				L							H	M
CO4	H	H	M				L							H	M
CO5	H	M		M	L						L			H	H

Course Topics

Unit 1: Navigation Basics

Navigation and Navigation system basics, Reference systems: Coordinate systems, Time systems

Satellite orbits: Orbit description, determination, and dissemination

Unit 2: Satellite Signals and Positioning

Satellite signals: Generic signal structure, Generic signal processing, Satellite positioning: Point positioning, Differential positioning.

Unit 3: GPS Basics

The Evolution, Development of NAVSTAR GPS, GPS working principle, Trilateration, Determination of satellites location, Determining the receiver position in 2D and 3D Plane, GPS observables

Unit 4: GPS Signals, Other Navigation Systems

GPS Segments, GPS Services, GPS Signals, GPS Data processing, Ionospheric effects of GPS signals

Other navigation systems (GLONASS, Galileo, IRNSS NAVIC) and their comparison with GPS

Unit 5: GPS Applications

Remote sensing, Engineering, and monitoring, Military applications, Geographical Information System, Vehicle tracking and car navigation, LBS and Special applications

X- Component Topics:

1 Tutorial on orbit planes reference points for GNSS and INS navigators.
2 Tutorial on antenna position in ECEF coordinates.
3 Tutorial on maximum Doppler shift due to satellite motion.
4 Tutorial on calculation of refection coefficient and standing wave ratio in GNSS antenna.
5 Tutorial on calculation of mismatch efficiency and return loss in GNSS antenna.
6 Tutorial on calculation of polarization and the input impedance for the antenna.
7 Tutorial on ADC output signal and signal level in dBm at the output of the receiver antenna.
8 Tutorial on high accuracy of the carrier phase measurements.
9 Tutorial on reducing the loop bandwidth and increasing the signal strength.
10 Tutorial on calculation of ionospheric delay using dual-frequency carrier phases.
11 Tutorial on calculation of frequency stability in Galileo signal strength.
12 Tutorial on calculation of PRN noise in modulation schemes.
13 Tutorial on Accuracy and Precision Measures - RMS accelerometer noise
14 Tutorial on Accuracy and Precision Measures - RMS gyro noise and gyro bias.
15 Tutorial on Accuracy and Precision Measures - RMS accelerometer bias and scale factor.

Textbooks:

1. Dr. Bernhard Hofmann-Wellenhof, Dr. Herbert Lichtenegger, Dr. Elmar Wasle, “GNSS — Global Navigation Satellite Systems: GPS, GLONASS, Galileo”, Springer, 2007.
2. Elliott D. Kaplan, Christopher J. Hegarty, “Understanding GPS/GNSS. Principles and Applications”, Artech, 2017.
3. https://nptel.ac.in/courses/105/107/105107062/

References:

1. Mohinder S. Grewal, “Global Positioning Systems, Inertial Navigation, and Integration”, Wiley, 2020 (Fourth Edition)
2. Shuanggen Jin, Estel Cardellach, Feiqin Xie, “GNSS Remote Sensing: Theory, Methods and Applications”, Springer, 2014.
3. G.S. Rao, “Global Navigation Satellite Systems: With Essentials of Satellite Communications”, McGraw Hill India, 2006.
4. Leick, Alfred, Rapoport, Lev, Tatarnikov, Dmitry, “GPS Satellite Surveying”, Wiley, 2015.
5. Ahmed El-Rabbany, “Introduction to GPS: The Global Positioning System”, Artech, 2017.
6. https://www.coursera.org/learn/geospatial

ELECTRONIC PRODUCT DESIGN

ECE21RXXXX	Electronic Product Design	L	T	P	X	C
		2	0	0	3	3
Pre-requisite	**:**	Basic Electronics				
Course Category	**:**	University Elective				
Course Type	**:**	Theory				

Course Description:

The course deals with product design from a broader, holistic perspective, integrating environmental responsibility into the core of the design process. It covers the cooling techniques, EMC safety standards, general design methodology and packaging. The course also will have topics in documentation of the product design.

Course Objective:

To bridge the major gap in competencies required to design, manufacture and market Indian state-of-the art electronics products.
To understand the stages of product design and development.
To understand the importance of following the standards and recycling.
To make them document the designed product

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Explain engineering design and development process in electronic products
- **CO2 :** Design products which would have high reliability.
- **CO3 :** Analyse thermal management and cooling techniques in electronic circuit design.
- **CO4 :** Analyse the importance of standards and recycling in design
- **CO5 :** Illustrate the importance of packaging and documentation in a product design

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M				L						M	H		L
CO2	H	M										H	H		L
CO3	H	H				L						L	H		L
CO4	M	M				L	M					L			L
CO5										M		L		M	M

Course Topics:

Unit 1: Product Design Basics

Design reviews, The Process of Identifying Customer Needs, Establishing Target Specifications, The Activity of Concept Generation-Five step method, Product Requirements, Communication, Engineering Economy, Life Cycle of Electronic Products, Design and Development Process

Unit 2: User Interface and Reliability

Input/Output, Sensors, Power supplies, Ergonomics, Design for Assembly, Reliability Parameters, Calculating Failure rates of Electronic Components

Unit 3: Thermal Management and Cooling

Thermal Management Parameters, Temperature of Components and Systems, Power dissipation in Electronic Components, Analogy between electrical and thermal parameters, Heat transfer modes: Conduction, Convection, and Radiation; Other cooling techniques

Unit 4: EMC, Standards, Recycling

EMC issues, Shielding from fields, EMC standards, Recommendation for EMC compliant systems design - System protection (CE designation and Protection classes); Vibration, Shock and Water protection - Recycling and Circular Economy: Manufacture, Use, and Disposal of Electronic Systems in the Circular Economy

Unit 5: Packaging and Documentation

Shipping Environments, Material Selection for packing, Testing package for Transportation, EPE Designer Output, Part Numbering, Version Control

X-Component:

1. Develop a list of customer needs and system-level requirements for an electronic product.
2. Identify the issues and establish the five-step concept generation method for the product and reflect it on the solution
3. Develop a list of customer needs and system-level requirements. Translate those needs into design requirements for Television
4. Case study of a Sensor Based Assisted Devices
5. Discuss Application of Design for Automated Assembly methods in the development of an electronic product from early design to design freeze
6. Product Design Improvement by Design for Assembly (DFA) Method for an electronics / electrical product like Steam Iron
7. Implementation of design for environment principles in product development using a case study.
8. Review on Environmental Impact over Product Life Cycle and Cooling Techniques for an electronics product like Apple Computer
9. Case study on EMI EMC Issues in Designing PCB
10. Article on ISO 26262 — Functional safety in the automotive industry
11. Case Study on Sustainable Packaging Design for Consumer Electronics Products; Balancing Marketing, Logistics and Environmental Requirements
12. Case Study: Implementation of Electronic Documentation on any Real time Projects

Textbooks:

1. Tony Serksnis, “Designing Electronic Product Enclosures”, Springer, 2019.
2. Jens Lienig, Hans Bruemmer, “Fundamentals of Electronic Systems Design”, Springer, 2017.
3. https://nptel.ac.in/courses/117/106/117106086/

References:

1. Karl T. Ulrich, Steven D. Eppinger, Maria C. Yang, “Product Design and Development”, McGraw-Hill, 2020 (Seventh Edition).
2. Mark I. Montrose, “Printed Circuit board design Techniques for EMC Compliance: A Handbook for Designers”, Wiley, 2015 (Second Edition).
3. Kim R. Fowler, “Electronic Instrument Design: Architecting for the Life”, Oxford University Press, 2016 (Third Edition).
4. Ali Jamnia, “Introduction to Product Design and Development for Engineers”, CRC Press, 2018.
5. https://nptel.ac.in/courses/107/103/107103082/
6. https://nptel.ac.in/courses/117/108/117108140/
7. http://sites.tufts.edu/eeseniordesignhandbook/

BIOSENSORS AND THEIR APPLICATIONS

ECE21RXXXX	Biosensors and their Applications	L	T	P	X	C
		2	0	0	3	3
Pre-requisite	**:**	Biology for Engineers				
Course Category	**:**	University Elective				
Course Type	**:**	Theory				

Course Description:

Know the principle of transduction, classifications and the characteristics of different transducers and study its biomedical applications

Course Objective:

Make Students to Understand the purpose of measurement, the methods of measurements, errors associated with measurements.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Analyse the principle and methods used for electrochemical cells.
- **CO2 :** Interpret the principle of transduction, classifications, and the characteristics of different transducers for various biomedical applications.
- **CO3 :** Explain the concepts, types, working and practical applications of important biosensors.
- **CO4 :** Identify the biological elements using optical technology
- **CO5 :** Identify the target antigen using immunosensor

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	L		H						L		L	H		
CO2	H	L			M					L		L	L	M	
CO3	H	H		H								L	H	L	L
CO4	H	H		H	M							H	H	L	
CO5	H	H		H	M					L		H	H	L	

Course Topics:

Unit 1: Biosensors Basics

Biosensors- Advantages and limitations, various components of biosensors Biocatalysts based biosensors, Bio affinity-based biosensors and Microorganisms based biosensors, biologically active material, and analyte. Types of membranes used in biosensor constructions.

Unit 2: Transducers for Biosensing

Various types of transducers; principles and applications - Calorimetric, Optical, Potentiometric / Amperometric, Conductometric / Resistometric, Piezoelectric, Semiconductor, Impedimetric, Chemiluminescence - based Biosensors.

Unit 3: Biosensors Applications

Biosensors in clinical chemistry, medicine and health care, biosensors for veterinary, agriculture and food Low cost - biosensor for industrial processes for online, monitoring; biosensors for environmental monitoring. Application of enzymes in analysis; design of enzyme electrodes and their application as biosensors in industry, healthcare, food, and environment.

Unit 4: Optical Technology for Biosensors

Principles of Optical Measurements, Absorption Spectroscopy, Reflectance Spectroscopy, Fluorescence, Phosphorescence, Oxyhaemoglobin and Oximetry, Digital Image Processing, Optodes, Optical Waveguides, Light-Addressable Potentiometric Sensor

Unit 5: Immunosensors

Potentiometric Immunosensors, Amperometric Immunosensors, Enzyme-Linked Immunoassays, Piezoelectric Microbalance Immunosensors, Bioluminescent Immunoassay Fluorescence Immunoassay, Surface Resonance, Laser Magnet Immunoassay

X-Component:

1 Introduction to various types of Biosensors.
2 Written report about chemical sensor and biosensor
3 Review of the article of electrochemical cells
4 To study about different types of Force Measurement Techniques.
5 To study about different types of Torque Measurement Techniques.
6 Introduction to Enzyme biocatalyst
7 Biosensor Microchip: Case study
8 To study about Electrochemical and optical Transduction
9 To study about various fabrication techniques spectroscopy
10 Written report about biological element
11 Recent developments in commercial biosensors- sensitivity and accuracy for detection of blood constituents (e.g., glucose, urea, creatinine) and disease biomarkers: Case study
12 Reviewing Research article about immunosensor.

Textbooks:

1. Donald G. Buerk, “Biosensors Theory and Applications”, CRC Press, 1995
2. Jeong-Yeol Yoon, “Introduction to Biosensors: From Electric Circuits to Immunosensors”, Springer, 2016
3. https://nptel.ac.in/courses/102/104/102104062/

References:

1. Renganathan S, “Transducer Engineering”, Allied Publishers, 2000.
2. R. Pethig and S. Smith, “Introductory Bioelectronics: for Engineers and Physical Scientists”, Wiley, 2012
3. Chandran Karunakaran, Kalpana Bhargava, Robson Benjamin, “Biosensors and Bioelectronics”, Elsevier, 2015
4. Donald G. Buerk -, “Biosensors Theory and Applications”, Technomic Publishing. Co, Inc, 1993
5. Gennady Evtugyn, “Biosensors: Essentials”, Springer, 2013
6. https://www.edx.org/course/principles-of-electronic-biosensors

IoT FOR SMART AGRICULTURE

ECE21RXXXX	IoT for Smart Agriculture	L	T	P	X	C
		2	0	0	3	3
Pre-requisite	**:**	IoT Sensors and Devices				
Course Category	**:**	University Elective				
Course Type	**:**	Theory				

Course Description:

This course introduces the basic concepts and applications of Internet of Things (IoT) technology in agriculture, and its impacts on farming and agricultural industry. Showcase of typical IoT systems used in farms, on farm equipment and in cloud and aims to provide hands on experience on essential IoT components, including hardware using sensors.

Course Objective:

• Understand how IoT technologies can be used in agriculture systems and affect an agriculture business.
• Understand the concept of IoT systems and its major architecture and components.
• Know typical IoT agricultural systems, understand the architecture and functionalities.
• Understand how to collect and analyse data with IoT for precision agriculture systems and strategically store and share data for public access;

Course Outcomes:

At the end of the course, the student will be able to:

CO1 : Describe the agricultural IoT concepts, characteristics, applications, examples, design challenges related to Embedded Systems
CO2 : Explain various techniques of monitoring the data and processing methods.
CO3 : Describe the implementation of the collaborative robotics for agriculture
CO4 : Explain the smart action in implementing the standards and recommendations of smart sensors
CO5 : Analyse the eco-social impact on precision farming and the technologies for smart farming

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	L	H	L		L		L						L	L	
CO2	L	L		L	M	L							M		
CO3		L	L	L	L			L					L	M	L
CO4			L	L	L	L	L	L					M	M	
CO5		M		L		L	L				M	L	M	L	L

Course Topics:

Unit 1: Smart Farming from A Multidisciplinary Perspective

Internet of things architectures and paradigms, Physical devices and controllers, Open-source internet of things platforms, Arduino, The solenoid valves, Relay, Moisture sensor, Rainfall sensor. From an object to a smart object, State of the art of smart objects, State of the art of cognitive techniques

Unit 2: Monitoring-Remote and Proximal Sensing

Remote Sensing, weed detection, detection of insects, crop disease detection, Spectral and thermal properties of plants in a nutshell, Spectral analysis methods to estimate N and water status in crop, Thermal image analysis to estimate water crop status, Proximal crop sensors, and proximal soil sensors. Integration of remotely sensed data in fertilization and irrigation decision making.

Unit 3: Smart Collaborative Robotics for Agriculture

Robotics and its role in agriculture, IoT and IoS in agriculture, Climate control, Automatic Sprayers, Fruit harvesting robots, Controllers for variable rate application, Actuators for variable rate application, Cyber-physical system in smart and precision agriculture

Unit 4: Plant Health Monitoring

Measurement of leaf health, chlorophyll detection, ripeness level, ripeness level, crop mapping, fertilizing, Drone technology for soil field analysis and assistive operations.

Unit 5: Technologies for Farming

Water quality monitoring, micro-irrigation system, Solar pump and lighting system, Fencing, Android based automation, Agricultural Robots, Standards for agriculture

X- Component Topics:

1 Connecting all sensors with Arduino and observing the values through serial monitor.
2 Creating an alarm if the value from the sensor reaches a particular limit
3 Design and development of water level tracker in a farm tank using IoT
4 Auto watering the plant and tracking plant's health through Microsoft Azure IoT.
5 Design and development of Temperature logging system
6 Designing a simple mobile APP integrating data using Thing speak platform
7 Design and development of air quality monitoring system using IoT.
8 Design of simple sprayer using Arduino (controlling the flow and direction)
9 Field Visit to soil testing centre
10 Brainstorming session on the applications of drone in agriculture
11 Design and development of pH monitoring system using IoT
12 Group Task on designing a mini green house

Textbooks:

1. Abdul Mouazen, Annamaria Castrignano, Olivier Naud, Raj Khosla, Gabriele Buttafuoco, Dimitrios Moshou, “Agricultural Internet of Things and Decision Support for Precision Smart Farming”, Academic Press, Elsevier, 2020.

2. Ajith Abraham, Joel José P. C. Rodrigues, Sujata Dash, Biswa Ranjan Acharya, Subhendu K. Pani, “AI, Edge, and IoT-based Smart Agriculture”, Elsevier, 2021.
3. https://onlinecourses.nptel.ac.in/noc19_cs65/preview

References:

1. Arindam Biswas, Amitava Choudhury, Amlan Chakrabarti, Manish Prateek, “Agricultural Informatics Automation Using the IoT and Machine Learning”, Wiley, 2021.
2. Souvik Pal, S. N. Panda, Prasant Kumar Pattnaik, Raghvendra Kumar, “IoT and Analytics for Agriculture”, Springer, 2019.
3. Ramesh C. Poonia, Linesh Raja, Xiao-Zhi Gao, “Smart Farming Technologies for Sustainable Agricultural Development”, IGI Global Publisher, 2018.
4. Anita Gehlot, Ajay Kumar Kaviti, Amit Kumar Thakur, Rajesh Singh, “Internet of Things for Agriculture 4.0 Impact and Challenges”, Taylor and Francis, 2021.
5. Faisal Karim Shaikh, Naeem Ahmed Mahoto, “IoT Architectures, Models, and Platforms for Smart City Applications”, IGI Global Publisher, 2019

IoT Network Architectures and Protocols

ECE21RXXXX	IoT Network Architectures and Protocols		L	T	P	X	C
			2	0	0	3	3
Pre-requisite	**:**	Basic C programming					
Course Category	**:**	University Elective					
Course Type	**:**	Theory					

Course Description:

This course is intended for non-circuital branch and computing branches. The students will be new to this course and this course will explain the basic concepts of IoT required to apply in any domain for the real-world applications.

Course Objective:

To understand basics of an IOT System, IoT architecture, IoT protocols, IoT network topologies and use them for real time IoT enabled domains.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Articulate a real world IoT application with the knowledge gained on IoT conceptual framework
- **CO2 :** Analyse the different network technologies for the IoT with an understating of its limitations, impact on society, and environment.
- **CO3 :** Explain the principles of layered networking models and standards existing for IoT.
- **CO4 :** Compare different communications protocols related to IoT.
- **CO5 :** Illustrate a basic IoT network design to a real-world application using the knowledge gained on graphical representation of IoT networks.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H					H						M	H		L
CO2	H	L	M	L	L	H	H	M					H	M	M
CO3	H												H		
CO4	H											L	H		
CO5	H	L	L			H	L	M				M	H		L

Course Topics:

Unit 1: IoT: An Overview

Internet of Things – Conceptual Framework – Architectural View – Technology behind IoT, Major components in IoT system – Sources of IoT – Machine to Machine Communication – Examples.

Unit 2: Networks

Types of Networks – Network process, packet switching, routing, converged networks, hosts, client/server model, IP address and configuration, components of networks, Bandwidth/throughput – Data through Network activity – Wireless systems and technologies, Wi-Fi, WAP, Bluetooth, NFC – Data vs Network Analytics – IoT Data Management, Fog, Edge, Cloud.

Unit 3: Standards, Layered Network Models

Networking standards – TCP model – Protocol Data Units – Encapsulation / Decapsulation – ITU IoT reference models – MAC addressing in Data link layer– IPv4 and IPv6 addresses – Comparison with MAC addresses – Routers and routing – TTL

Unit 4: IoT Protocols

Application protocols, CoAP, MQTT – Transport protocols – Internet protocols – RPL, CORPL, CARP, Physical protocols – IoT LAN and WAN – PAN - Zigbee - IEEE 802.15.4 overview – LPWA technologies such as LoRa and Sigfox.

Unit 5: Designing an IoT network

Topological structures – logical topology, types, methods to draw – Physical topologies, Methods to draw – Design consideration of IoT network and protocols – Industrial IoT: Manufacturing, Oil and Gas, Smart and Connected Cities, Transportation – Impact of IoT in emergency medical services.

X- Component Topics:

1 Teaching about drawing the conceptual framework for smart umbrella.
2 Illustrating M2M model and comparing the wearable smart watches in terms of IoT point of view.
3 Explaining additional layer required for application support for IoT/M2M.
4 Case study on Murchison Widefield array and discuss about the throughput and components of the network,
5 Illustrative example of networking in packet tracer
6 Use packet tracer to learn the concepts of routing
7 Define a small problem in day-to-day life and discuss how to solve with IoT
8 Drag and drop activities to understand the concept of IoT protocols
9 Make use of Link Labs for interactive learning – change the specifications and discuss the comparative points between types of IoT protocols such as Bluetooth vs Zigbee etc.
10 Discussing roe of IoT in ATM premises monitoring projects
11 Case studies on how IoT connects cars and its services
12 Explaining the major role of hardware and software components in IoT smart homes.

Textbooks:

1. Raj Kamal, “Internet of Things, Architecture and Design Principles”, McGraw-Hill, 2017 (Fifth Edition).
2. Cirani, Simone, “Internet of Things: Architectures, Protocols, and Standards”, Wiley, 2018 (Third Edition).
3. https://onlinecourses.nptel.ac.in/noc21_cs17/preview
4. https://learning.edx.org/course/course-v1:CurtinX+IOT3x+1T2021/home

References:

1. Hanes, D., Salgueiro, G., Grossetete, P., Barton, R., and Henry, J., “IoT fundamentals: Networking Technologies, Protocols, and Use cases for the Internet of Things”, Cisco Press., 2017.
2. Adrian McEwen and Hakim Cassimally, “Designing the Internet of Things”, Wiley, 2015 (Second Edition).
3. A. Bahga and V. Madisetti, “Internet of Things: A hands on Approach”, Universities Press, 2015 (Second Edition).

ARM SYSTEM ARCHITECTURE

ECE21RXXX	ARM System Architecture	L	T	P	X	C
		2	0	0	3	3
Pre-requisite	:					
Course Category	:	University Elective				
Course Type	:	Theory				

Course Description:

This course is to give the students a thorough exposure to ARM architecture and make the students to learn the ARM programming models

Course Objective:

This course will enable students to: • Understand the importance and applications of ARM Design • Know the architecture of ARM processor

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Explain the ARM Processor fundamentals.
- **CO2 :** Analyse the interfacing Concepts of ARM processor.
- **CO3 :** Examine the ARM interrupts configuration concepts
- **CO4 :** Explore the Timers/Counters concepts of ARM
- **CO5 :** Demonstrate advanced ARM applications

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M											H		
CO2	H	H											H	M	
CO3	H	H	M	M									H	M	
CO4	H	H	M	M									H	M	
CO5		H	M		H	M	L	M	M	M	M	L	H	M	M

Course Topics:

Unit 1: ARM Processor

Introduction, Features of ARM, ARM Processor Family, LPC2148 Microcontroller, General Purpose Input Output pins, Registers associated with the GPIO

Unit 2: ARM Interfacing

Interfacing 16 X 2 LCD with LPC2148 ARM 7 Microcontroller, LPC2148 Pin Configuration, Interfacing LCD Module with LPC2148

Unit 3: ARM Interrupts

Interrupt Tutorial, Interrupt Related Registers in LPC2148, Configuring Interrupts in LPC2148

Unit 4: ARM Timers

Timers / Counters in LPC2148, Registers Associated with Timers in LPC2148, configuring timers, Blinking LEDs using LPC2148 and Timers

Unit 5: ARM Applications

Introduction, PWM in LPC2148, Registers in LPC2148, Configuring PWM in LPC2148, Basics of UART, UART in LPC2148, Registers associated with UART in LPC2148, Example-Blinking LED.

X-Component

1 Development toolchain like integrated development environment (IDE), compiler, debugger, and simulator.
2 Blink alternate LED using Ports
3 Writing the programming the LCD interface with LPC2148
4 Simple circuit using I/O pins
5 Stepper motor Interfacing with LPC2148
6 Blinking a set of LEDs using Timers and Interrupts.
7 Setup and configure the timers
8 Blinking LED using Timers with an efficient delay
9 Dimming the LED using PWM.
10 Baud rate generation in UART
11 LED blinking rate with serial communication.

Textbooks:

1. Jonathan W. Valvano, "Realtime Operating Systems for ARM Cortex-M Microcontrollers", CreateSpace Independent Pub, 2017 (Fourth Edition)
2. Rajkamal, "Embedded System", McGraw Hill, 2015 (Third Edition)
3. https://www.electronicshub.org/arm-tutorial/

References:

1. Andrew Sloss, Dominic Symes, and Chris Wright, "ARM system Developer's Guide", Elsevier, 2015 (Second Edition)
2. Steve Furber, "ARM system On Chip Architecture", Addison Wesley, 2016 (Second Edition)
3. Dr. Yifeng Zhu, "Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C", E-Man Press LLC, 2018 (Third Edition)
4. Joseph You, "System on Chip with ARM Cortex M Processors", ARM Education media, 2019
5. Amir Sabbagh Molahosseini, Leonel Seabra de Sousa, Chip-Hong Chang (eds.), "Embedded Systems Design with Special Arithmetic and Number Systems", Springer, 2017
6. https://nptel.ac.in/courses/117/106/117106111/
7. https://nptel.ac.in/courses/108/102/108102045/

GREEN ELECTRONICS MANUFACTURING

ECE21RXXXX	Green Electronics Manufacturing	L	T	P	X	C
		2	0	0	3	3

Pre-requisite	**:**	Basic Electronics
Course Category	**:**	University Elective
Course Type	**:**	Theory

Course Description:

The Green Electronics Manufacturing is designed as a course which discusses the regulations of the green electronics as the priority. After that the green electronic materials, process, assembly, recycling is covered extensively. Finally, the e waste management policy in India is discussed.

Course Objective:

Green manufacturing focuses on reducing parts, rationing materials, and reusing components. This course teaches the strategies and process behind the green manufacturing which allows electronics manufacturers to create environmentally friendly products while maintaining the same quality and reliability of the electronics they produce presently.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Explain the relevant regulations and RoHs.
- **CO2 :** Analyse the usage of green materials and mitigate Tin Whisker Risk
- **CO3 :** Describe the green electronic assembly and formulate the fatigue life prediction
- **CO4 :** Analyse the recycling strategy and disassembly in green electronics manufacturing
- **CO5 :** Explain the Indian standard practices regarding the green electronics.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1						H	H	H				M			M
CO2	M	H					H					L	L		M
CO3	M	H					H					L	L		M
CO4	M						H					L	L		M
CO5	H					H	H	H				M		L	M

Course Topics:

Unit 1: Green Electronics Basics

Environmental concerns of the modern society – Electronics industry and their relevant regulations in China, European Union, and India. Restriction of Hazardous substances (RoHs) – Waste Electrical and electronic equipment (WEEE) – Energy using Product (EUP) and Registration Evaluation, Authorization and Restriction of Chemical substances (REACH)

Unit 2: Green Electronic Materials

Lead (Pb) – free solder pastes, conductive adhesives, halogen-free substrates, and components. Substitution of non-recyclable thermosetting polymer-based composites with recyclable materials X-Ray Fluorescence (XRF) for identifying hazardous substances in electronic products. Tin Whiskers Growth in Lead-Free Electronic Assemblies – Factors Influence Whisker Growth – Ways to Mitigate Tin Whisker Risk – Use Finite Element Modelling to Assess Tin Whisker Risk

Unit 3: Green Electronic Assembly

Green electronic Assembly – Soldering Process – Lead-Free Solder Tip and Bumps – Mitigate Deterioration of Lead-Free Tin Solder at Low Temperatures – Fatigue Characterization of Lead-Free Solders – Thermal Fatigue of Solder Joints, Fatigue Design of Lead-Free – Electronics – Fatigue Life Prediction Based on Field Profile, Fatigue Validation of Lead-Free Circuit – Flip-Chip Technology and Assembly process – card Assembly, surface mount technology

Unit 4: Green Electronics Recycling

Management on e-waste recycle system construction – global collaboration and product disassemble technology - Occupational and environmental health perspectives of e-waste recycling. Case study-Lead Free Electronic Design

Unit 5: e-Waste Management in India

Shadows of digitization on India, Present practice and systems, disposal methods, Present processing practices – Initiatives to manage e-waste

X- Component Topics: / Laboratory Experiments:

1 Regulations and Policy Decisions in QUAD Countries (US, Japan, Australia, and India)

2 (a) Statistical Analysis of Green Electronics Products (Design of Experiment)
(b) Application of REACH (Tutorial)

3 (a) Design a master plan for implementing the use of green materials and process in New Products (Design Problem)

4 (a) Study of Allotropic Transformation of Tin. (Modelling)
(b) Study of Diffusion and the Formation of Copper–Tin Intermetallic (Tutorial)

5 Understanding of FEM Analysis with Tin Whisker Risk calculation. (Case study)

6 Design Control for Leaded versus Lead-Free Boards in RoHS Complaint (Design Problem)

7 Study of Fatigue and Thermal Fatigue of Solder Joints. (Industrial Case Study)
Calculating the number of cycles to failures when a chip resistor of length d is soldered to the surface of PCB. (Tutorial)

8 Mathematical Modelling of Fatigue Life Prediction

9	Design of Lead-Free Electronics using Weibull distribution (Design Problem on Life Testing Data Analysis using Regression)
10	(a) Study of Time-Independent Plasticity Model for recycling (Design of Experiment) (b) Study of Motorola/Deveraux's Constitutive Model to predict recycling levels (Tutorial)
11	(a) Using Regression implement a study on Lead Free Electronic Design. (Case Study) (b) Study on Government Policies to recycle Electronic Products in India (Data collection from https://greene.gov.in/)
12	(a) Case Study on E Waste from Mobile Phones (Statistical Analysis) (b) Case Study on E waste with New Generation Flexible Electronics or VAPR

Textbooks:

1. Sammy G Shina, "Green Electronics Design and Manufacturing", MC Graw Hill, 2008.
2. Mihai Irimia-Vladu, Eric D. Glowacki, Niyazi S. Sariciftci, Siegfried Bauer, "Green Materials for Electronics", Wiley, 2017.

References:

1. John X Wang, "Green Electronics Manufacturing: Creating Environmental Sensible Products", CRC Press, 2013.
2. Gadi Eisenstein, Dieter Bimberg, "Green Photonics and Electronics", Springer, 2017.
3. Lee H Goldberg, "Green Electronics/Green Bottom Line", Elsevier, 1999.
4. Majeti Narasimha Vara Prasad, Meththika Vithanage and Anwesha Borthakur, "Handbook of Electronic Waste Management: International Best Practices and Case Studies", Springer, 2019.
5. Bruce Fowler, "Electronic Waste: Toxicology and Public Health Issues", Elsevier, 2017.
6. Albert Sabban, "Innovation in Global Green Technologies 2020", Intech Open, 2020.

ELECTRONICS PACKAGING

ECE21RXXXX	Electronics Packaging	L	T	P	X	C
		2	0	0	3	3
Pre-requisite	**:**	Basic Electronics				
Course Category	**:**	University Elective				
Course Type	**:**	Theory				

Course Description:

Electronic packaging is the design and production of enclosures for electronic devices ranging from individual semiconductor devices up to complete systems

Course Objective:

Packaging of an electronic system must consider protection from mechanical damage, cooling, radio frequency noise emission and electrostatic discharge. Product safety standards may dictate features of a consumer product, for example, external case temperature or grounding of exposed metal parts. This course focuses on the basics, anatomy, assembly requirement, CAD utilized and reliability testing.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Explain the electronic packaging and materials.
- **CO2 :** Analyse the system package, power distribution, clocking strategies and RF Issues.
- **CO3 :** Analyse the IC assembly by different levels of packaging and testing.
- **CO4 :** Describe the anatomy of PCB and its thermal managements.
- **CO5 :** Analyse the reliability testing, system level testing for packaging.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H											M	M		M
CO2	M	H	L	L	L	M						M		L	M
CO3	M	H	L	M								M			M
CO4	M											M	M		M
CO5	M		L									M	M		M

Course Topics:

Unit 1: Electronics Packaging Basics

Functions of an Electronic Package – Packaging Hierarchy – IC packaging: MEMS packaging, consumer electronics packaging, medical electronics packaging – Trends, Challenges. Driving Forces on Packaging Technology – Materials for Microelectronic

packaging. Packaging Material Properties – Ceramics, Polymers, and Metals in Packaging – Material for high density interconnect substrates.

Unit 2: Anatomy of Systems Packaging

Electrical Anatomy of Systems Packaging – Signal Distribution, Power Distribution- Familiarization of LT POWER CAD (Analog Device) or equivalent, Electromagnetic Interference. Design Process Electrical Design: Interconnect Capacitance, Resistance, and Inductance fundamentals; Transmission Lines, Clock Distribution, Noise Sources, power Distribution, signal distribution. EMI – Digital and RF Issues. Processing Technologies, Thin Film deposition, Patterning, Metal to Metal joining.

Unit 3: IC Packaging

IC Assembly – Purpose, Requirements, Technologies, Wire bonding, Tape Automated Bonding – Flip Chip. Wafer Level Packaging – reliability, wafer level burn – in and test. Single chip packaging: functions, types, materials processes, properties, characteristics, trends. Multi chip packaging: types, design, comparison, trends. Passives: discrete, integrated, embedded encapsulation and sealing: fundamentals, requirements, materials, processes. - Issues in Multi-chip Modules -Future of MCM Packaging.

Unit 4: Printed Circuit Board

Anatomy, CAD tools for PCB design – Standard fabrication – Micro via Boards. - Familiarization of Autodesk Eagle (Opensource) or equivalent. Board Assembly: Surface Mount Technology, Through Hole Technology – Process Control and Design challenges. Thermal Management – Heat transfer fundamentals – Thermal conductivity and resistance – Conduction, convection, and radiation – Cooling requirements.

Unit 5: Reliability Testing

Reliability, Basic concepts – Environmental interactions. Thermal mismatch and fatigue – failures – thermos-mechanically induced – electrically induced – chemically induced. Electrical Testing: System level electrical testing, Interconnection tests, Active Circuit Testing, Design for Testability- Special Case of Hardware and Software Beta Testing

X- Component Topics:

1 Develop the Phases of a Typical 3DIC Packaging System Flow Project (Design of Experiment using ISO 9000)

2 Study on adhesives used in Electronics Packaging. (Design of Experiment)

3 (a)Study on how and why RF energy is created within the PCB. (Tutorial)
(b)Design a Power Distribution network using LT POWER CAD (Case Study)

4 (a)Study of Microstrip Topology qualified Transmission Line in PCB (Case Study)
(b) Design a power distribution model for a loop control given in PCB. (Case Study)

5 (a) Relate the Digital and RF Issues related to Transmission Lines. (Tutorial)

6 (a) Compare the Flip Chip Technology with other mounted technology (Tutorial)

7 (a) Differentiate the Laminate MCM, Ceramic MCM, Thin Film MCM and study the manufacturing steps (Tutorial)
(b) Identify the Conditions where MCM needs to be utilized (Design of Experiment)

8 (a) Develop a design flow for Printed wiring boards which can work with DRC. (Design of Experiment

9 Design a PCB with Auto Desk Eagle (Open-source CAD) (Design of Experiment)

10 (a) Study of Heat Removal/Cooling in the Design of Packaging Systems. (Tutorial)

11 (a) Identify the different types of manufacturing faults and performance faults (Case Study)

12 Mind Mapping of Software Test Versus Hardware Test. (Case Study)
(a) Case study on Beta Test for HW-SW
(b) Case study on a stress test for an audio product that is expected to be used indoors. Expected shipping/storage temperature extremes are –30° to +70° C, expected +15° C with power off to +55° C with power on.

Textbooks:

1. Glenn R. Blackwell, "The Electronic Packaging Handbook", CRC Press, 2017.
2. Bernard S. Matisoff, "Handbook of Electronics Packaging Design and Engineering", Springer, 1990.

References:

1. Li, Yan, Goyal, Deepak, "3D Microelectronic Packaging", Springer, 2017.
2. Che, Faxing; Jin, Cheng; Lin, Tingyu; Zhao, Wensheng, "Modeling, Analysis, Design and Tests for Electronics Packaging Beyond Moore", Elsevier, 2019.
3. Peter Sandborn, "Cost Analysis of Electronic Systems", WSPC Series in Advanced Integration and Packaging, 2017 (Second Edition).
4. Lu, Daniel, Wong, C.P., "Materials for Advanced Packaging", Springer, 2018.
5. Ho-Ming, Tong, Lai, Yi-Shao, Wong, C.P., "Advanced Flip Chip Packaging", Springer, 2013.
6. Lau, John H., "Heterogeneous Integrations", Springer, 2019.

VLSI DESIGN

ECE21RXXXX	VLSI Design	L	T	P	X	C
		2	0	0	3	3
Pre-requisite	:	Basic Electronics				
Course Category	:	University Elective				
Course Type	:	Theory				

Course Description:

This is an introductory course which covers basic theories and techniques of digital VLSI design in CMOS technology. In this course, we will study the fundamental concepts and structures of designing digital VLSI systems include CMOS devices and circuits, CMOS design rules, static and dynamic logic structures, CMOS chip layout, CMOS Based Combinational circuit design and Sequential Circuit design.

Course Objective:

In this course students will learn how to analyse and design CMOS digital circuits and optimize them with respect to different constraints such as size (cost), speed, power dissipation.

Course Outcomes:

At the end of the course, the student will be able to:

CO1 : Design simple logic gates using CMOS logic style
CO2 : Calculate power and delay of simple CMOS circuits
CO3 : Describe fabrication processes and their impact on the circuit performance
CO4 : Design combinational and sequential circuits using different logic styles

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	H					H					M	H	H	
CO2	H	H					H					M	H	M	
CO3	H	H					H					M	H	H	L
CO4	H	H					H					M	H	H	L

Course Topics:

Unit 1: VLSI Design Basics

Evolution, Application, Quality metrics, Design styles, VLSI Design flow, Physical Design Cycle, MOS Transistor Basics, CMOS Logic.

Unit 2: CMOS Circuit Characterization and Performance Estimation

DC transfer Characteristics of CMOS inverter, Second order effects, Circuit characterization and performance estimation: Delay estimation, Logical effort and Transistor Sizing, Power Dissipation: Static and Dynamic Power Dissipation.

Unit 3: CMOS Digital Design

CMOS Inverter, Transmission Gate - CMOS NAND Gate – CMOS NOR Gate – Simple function implementation using CMOS

Unit 4: CMOS Combinational circuit Design

Combinational Digital Circuit, Single bit Adder, carry look ahead adder, Magnitude Comparator, Signed and unsigned multiplier.

Unit 5: CMOS Sequential circuit Design

Sequential Digital Circuit, Conventional CMOS Latches: Pulsed Latches, Resettable and Enabled Latches, CMOS Flip Flops

X- Component Topics:

1 Study of various IC Technologies.
2 Study of IC parameters from its datasheet.
3 Design and verify the CMOS inverter circuit using transient analysis.
4 Design CMOS transmission gate and perform the analysis to verify its characteristics.
5 Design NAND, NOR using CMOS
6 Design all gates (except NAND, NOR) 2-input using CMOS logic.
7 Design a Boolean equation using CMOS
8 Design a CMOS Full adder
9 Design a 2:1 Multiplexer using CMOS
10 Design layout of CMOS Magnitude Comparator.
11 Design of D flipflop using CMOS Logic.
12 Design of JK flipflop using CMOS Logic.

Textbooks:

1. Neil H. Weste, Harris, A. Banerjee, “CMOS VLSI Design, A Circuits and System Perspective”, Pearson, 2014 (Fourth Edition).
2. https://nptel.ac.in/courses/117/106/117106092
3. https://nptel.ac.in/courses/117/101/117101058

References:

1. Jan M. Rabaey, Anantha Chadrakasan, BorivojeNikolic, “Digital Integrated Circuits: A Design Perspective”, Prentice Hall, 2014, (Third Edition).
2. Partha Pratim Sahu, “VLSI Design”, McGraw Hill, 2013.
3. Vikrant Vij, Nidhi Syal, “VLSI Design Theory and Practice”, University Science Press (Laxmi Publications), 2013.

FUNDAMENTALS OF WIRELESS COMMUNICATIONS

ECE21RXXXX	Fundamentals of Wireless Communications	L	T	P	X	C
		2	0	0	3	3
Pre-requisite	**:**	Basic Electronics				
Course Category	**:**	University Elective				
Course Type	**:**	Theory Course				

Course Description:

This course aims to provide students with a detail knowledge on fundamentals of wireless communication and explains the web of concepts underpinning these advances at a level accessible to an audience with a basic background in probability and digital communication.

Course Objective:

The objectives of this course are:

- To study about the various communication techniques, coding, opportunistic communication, TDMA and CDMA
- To study about concepts of illustrated using many examples from wireless systems such as GSM, IS-95 (CDMA) and UMTS systems
- To study the wireless Networking

Course Outcomes:

At the end of the course, the student will be able to:

CO1 : Represent signals mathematically in both analog and digital modulation
CO2 : Design the various coding techniques meeting the wireless communication
CO3 : Discuss about various modern wireless communication systems
CO4 : Explain various multiple access techniques
CO5 : Compare various wireless networking concepts

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	M										L	H		L
CO2	H	L										M	M		L
CO3	L	L					L					M	M		L
CO4	M	L					L					L	L		L
CO5	H	L				L						M	L		L

Course Topics:

Unit 1: Modulation Techniques for Mobile Radio

Amplitude Modulation, Angle Modulation, Frequency Modulation, Digital Modulation: An Overview- Line Coding- Pulse Shaping Techniques, Linear Modulation Techniques, Constant Envelope Modulation, Spread Spectrum Modulation Techniques.

Unit 2: Channel and Speech Coding

Fundamentals of Equalization, RAKE Receiver, Block Codes and Convolutional Codes, Adaptive Differential Pulse Code Modulation (ADPCM), Frequency Domain Coding of

Speech, Vocoders, Speech Codecs for Mobile Communications- The GSM Codec - The USDC Codec.

Unit 3: Modern Wireless Communication Systems

Case Study: AMPS, United States Digital Cellular (IS-54 and IS-136), Global System for Mobile (GSM), CDMA Digital Cellular Standard (IS-95), Digital European Cordless Telephone (DECT).

Unit 4: Multiple Access Techniques for Wireless Communications

Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Spread Spectrum Multiple Access, Space Division Multiple Access (SDMA).

Unit 5: Wireless Networking

Introduction to Wireless Networks, Traffic Routing in Wireless Networks, Wireless Data Services. Common Channel Signalling (CCS), Integrated Services Digital Network (ISDN), Signalling System No. 7 (SS7), Case Study: Universal Mobile Telecommunication System (UMTS).

Laboratory Experiments:

1 Implement Amplitude Modulation /Frequency Modulation Using Matlab
2 Implement Line Coding Using Matlab
3 Implement Direct Sequence Spectrum Using Matlab
4 Implement CRC Using Matlab
5 Implement Pulse Code Modulation Using Matlab
6 Implement GSM Encode and Decoder Using Matlab
7 Implement Modulation and Demodulation technique for GSM communication using Matlab
8 Implement CDMA transmission and reception of signals using Matlab.
9 Implement how data has been transmitted and received through FDMA Using Matlab
10 Implement how data has been transmitted and received through TDMA Using Matlab
11 Create a simple LAN network through routing technique with CISCO packet tracer.
12 Create a simple Cellular network using CISCO packet tracer

Textbooks:

1. Theodore S. Rappaport, “Wireless Communications Principles and Practice”, Prentice Hall, 2017 (Second Edition).
2. David Tse and Pramod Viswanath, “Fundamentals of Wireless Communication”, Cambridge University Press, 2015 (Second Edition).
3. https://nptel.ac.in/courses/117/102/117102062/

References:

1. Aftab Ahmad, “Wireless and Mobile Data Networks”, Wiley, 2015 (Second Edition).
2. Gordon Gow, Richard Smith, “Mobile and Wireless Communications: An Introduction”, McGraw Hill, 2016.

EXPERIENTIAL CORE, EXPERIENTIAL ELECTIVE

CAPSTONE PROJECT

ECE21RXXX	Capstone Project	L	T	P	X	C
		0	0	30	0	10

Pre-requisite	**:**	Completed Third Year
Course Category	**:**	Experiential Core
Course Type	**:**	Project

Course Description

The purpose of the Capstone Project is for the students to apply theoretical knowledge acquired during the program to a project in a realistic setting. During the project, students engage in the entire process of solving a real-world engineering project, from collecting and processing actual data to applying suitable, appropriate analytic methods and formulate solutions to the problem. Both the problem statements for the project assignments and the data originate from real-world domains like those that students might typically encounter within industry, government, non-governmental organizations (NGOs), or academic research.

Course Objective:

To introduce students to engineering projects; To provide students an opportunity to exercise their creative and innovative qualities in a group project environment of industries, real time applications; To excite the imagination of aspiring engineers, innovators and technopreneurs

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Design and develop solutions for the problems identified by applying their knowledge and skills acquired.
- **CO2 :** Assess the various scientific literature relevant to the problem identified.
- **CO3 :** Develop the designed system and interpret the results using various tools and equipment to make a conclusion on the system's working.
- **CO4 :** Practice professional and ethical responsibility in their work, written and oral presentation.
- **CO5 :** Develop soft skills in management, team skill, leadership skill and responsibilities while doing a project.
- **CO6 :** Incorporate engineering standards and realistic constraints namely(a) Economic analysis; (b) Environmental analysis; (c) Sustainability analysis; (d) Health and Safety analysis; (e) Social Issues while working on a project.

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	H	H									L	H		L

CO2	L	H										H	M		H
CO3			L	H	H									H	
CO4								H		H				M	M
CO5									H	L	M			M	
CO6						H	H				H	H		M	H

Course Topics

In consultation with the project guide, the team will propose, conduct, and report on a major project of industrial / community requirements that synthesizes and applies the knowledge and skills learned in the courses that comprised the student's degree program. The department project coordinator will assess the work through periodical reviews by a Project Review Committee. Upon completion of the project, the team will have to submit a project report which will be evaluated by duly appointed examiner/s. The evaluation will be based on the report and a viva voce examination on the project.

COMMUNITY SERVICE PROJECT

ECE21RXXX	Community Service Project	L	T	P	X	C
		0	0	8	0	4
Pre-requisite	**:**	Completed IV Semester				
Course Category	**:**	Experiential Elective				
Course Type	**:**	Project				

Course Description

"Community service," a well-known term in community programming, has its own definition: "the voluntary action of an individual or group of individuals without pay". The student(s) as an individual or team will design, develop, and execute a project for an identified community by them.

Course Objective:

The emphasis of this course is to enable third year engineering students to participate in an interdisciplinary team effort to apply engineering principles to solve open-ended problems that will have some significant societal impact.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Formulate and compose solutions for open-ended, real-life, various small to large scale problems.
- **CO2 :** Apply the concept of theory to practice.
- **CO3 :** Develop the designed system and interpret the results using various tools and equipment to make a conclusion on the system's working.
- **CO4 :** Practice professional and ethical responsibility in their work, written and oral presentation.
- **CO5 :** Demonstrate the ability to function in interdisciplinary teams and individually.
- **CO6 :** Incorporate engineering standards and realistic constraints namely(a) Economic analysis; (b) Environmental analysis; (c) Sustainability analysis; (d) Health and Safety analysis; (e) Social Issues, while working on a societal project

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	H	H	H									L	H		L
CO2	H	H	L	L	M								M	H	
CO3			L	H	H									H	
CO4								H		H				M	M
CO5								L	H					M	M

CO6						H	H				H	H		M	H

Course Topics

A project team comprises of 3 to 5 UG students can do the project in association with Community Service agencies like NGOs and School Students. The progress of the students in the Community Service Project be assessed through two periodical reviews by a Project Review Committee. The assessment will be based on the need analysis survey, execution of project and final installation at the community.

INTERNSHIP

ECE21RXXX	Community Service Project	L	T	P	X	C
		0	0	8	0	4

Pre-requisite	**:**	Completed IV Semester
Course Category	**:**	Experiential Elective
Course Type	**:**	Project

Course Description

Internships are off-campus experiential learning activities designed to provide students with opportunities to make connections between the theory and practice of academic study and the practical application of that study in a professional work environment. Internships offer the opportunity to "try out" a career while gaining relevant experience and professional connections. Internships are completed under the guidance of an on-site supervisor and a faculty, who in combination with the student will create a framework for learning and reflection. The students shall undergo industrial training / intern for a minimum period as specified in the regulations. At the end of the training, students shall submit a report and make a presentation which will be assessed by a committee constituted by the department.

Course Objective:

The emphasis of this course is to enable third year engineering students to participate in an interdisciplinary team effort to apply engineering principles to solve open-ended problems that will have some significant societal impact.

Course Outcomes:

At the end of the course, the student will be able to:

- **CO1 :** Formulate and compose solutions for open-ended, real-life, various small to large scale problems.
- **CO2 :** Apply the concept of theory to practice.
- **CO3 :** Develop the designed system and interpret the results using various tools and equipment to make a conclusion on the system's working.
- **CO4 :** Practice professional and ethical responsibility in their work, written and oral presentation.
- **CO5 :** Demonstrate the ability to function in interdisciplinary teams and individually.
- **CO6 :** Incorporate engineering standards and realistic constraints namely(a) Economic analysis; (b) Environmental analysis; (c) Sustainability analysis; (d) Health and Safety analysis; (e) Social Issues, while working on a societal project

Mapping of Course Outcomes:

CO / PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3

CO1	H	H	H									L	H		L
CO2	H	H	L	L	M								M	H	
CO3			L	H	H									H	
CO4								H		H				M	M
CO5								L	H					M	M
CO6						H	H				H	H		M	H

Course Topics

Students undertake a significant experiential learning opportunity, typically with an industry, company, non-profit or governmental organization. The internship represents an educational strategy that links classroom learning and student interest with the acquisition of knowledge in an applied work setting. The assessment of Internship will be conducted by the department after completing the industrial training / internship. The progress of internship will be accessed through periodic reviews by a Review Committee. Upon completion of the Internship or industrial Training, the student will have to submit a project report which will be evaluated by duly appointed internal examiner/s. The evaluation will be based on the report and a viva voce examination on the internship.