



Vidyalankar Institute of Technology

An Autonomous Institute affiliated to University of Mumbai

Bachelor of Technology In Electronics and Computer Science

Third Year Scheme & Syllabus (R 2024)

(As per NEP 2020, with effect from the Academic Year 2024-25)

Preamble

The National Education Policy (NEP) framework aims to break the mold from teacher centric to student centric educational practices. It empowers the students with flexibility in terms of choosing courses across different faculties and modes of learning.

This multidisciplinary approach will encourage learners to follow their passion and inherent interests. The learner is free to learn at a pace that he is comfortable with, and this enables lifelong learning. It also enhances the scope for holistic personality development.

This premise is truly reflected in preamble of the NEP document, "The future of nation is decided in the classrooms of the schools and colleges today".

Details of implementation:

NEP curriculum framework enables us to accelerate change, redesign systems with equity in mind, respond to feedback, encourage collaboration, catch and pollinate ideas and create a culture of research and development. It will allow us to offer the required academic flexibility which will focus on improving competency level of students with diverse strengths.

The curriculum planned by VIT has vertical **Program Courses** consisting of Programme core courses (PCC) of branch of engineering positioned and sequenced to achieve sequential and integral learning of the entire breadth of the specific branch. This vertical also includes Programme elective courses (PEC) which offer flexibility and diversity to learners to choose specialization from a basket of recent developments in their field of technology. The selection of unique professional elective courses based on industrial requirements and organizing them into tracks is a special feature of this curricula ensuring employability.

The vertical **Multidisciplinary Courses** consists of Open Elective (OE) courses and multidisciplinary minor (MD M) courses. Special vocational and skill development courses are included as a part of **Skill courses** vertical that make student capable to work in industrial environment.

The student is expected to demonstrate their ability through courses in **Experiential Learning Courses** vertical like internships/On Job Training, Community Engagement Project, Real Industry Project/ research problem. Our curriculum also introduces Social Service Internship and Internship with institutes abroad along with courses like Design Thinking. This will lead to the creation of products and/ or patents through this program.

For holistic development of students, apart from technical courses, Ability Enhancement Courses, Entrepreneurship/Economics/Management Courses, Indian Knowledge System and Value Education courses from vertical **Humanities and Social Science and Management** develop the required soft-skills and attitude amongst learners.

In **Liberal Learning** vertical courses like Various Dance Forms, Global citizenship Education, Facets of Astronomy etc. aim to create balance in brain hemispheres and hence improve learners' clarity in thoughts and responses.

In addition to core courses, professional and open electives; our framework offers honor degree in each programme of engineering. It includes specialized courses along with field/ domain study that make students capable of working on industry relevant problems.



Chairperson, Board of Studies
Department of Electronics and Computer Science
Vidyalankar Institute of Technology



Chairperson, Academic Council
Vidyalankar Institute of Technology

Third Year B. Tech. Electronics and Computer Science
Course Structure and Assessment Guidelines

Semester: V

Course			Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@40% of total marks)
NEP-Vertical	Code	Name			ISA	MSE	ESE	
PC-PCC	PCEC08T	Basic VLSI Design	Theory	2	15	20	40	075
	PCEC08P	Basic VLSI Design Lab	Practical	1	25	-	25	050
PC-PCC	PCEC05T	Signals and Systems	Theory	2	15	20	40	075
	PCEC05P	Signals and Systems Lab	Practical	1	25	-	25	050
PC-PCC	PCEC09T	Microcontroller and Applications	Theory	2	15	20	40	075
	PCEC09P	Microcontroller and Applications Lab	Practical	1	25	-	25	050
PC-PCC	PCEC11T	Analysis of Algorithms	Theory	2	15	20	40	075
	PCEC11P	Analysis of Algorithms Lab	Practical	1	25	-	25	050
PC-PEC	PEECxxT	Programme Elective-1	Theory	2	15	20	40	075
	PEECxxP	Programme Elective-1 Lab	Practical	1	25	-	25	050
MC-MDM	MDMXX	Multidisciplinary Minor Course-3	Theory	4	45	30	50	125
MC-OE	OEC15	Professional Competency Development 2	Practical	1	50	-	-	050
ELC	PRJEC01	Mini Project 1	Practical	2	25	-	50	075
Total Credits				22				
Course credits completed during the previous inter semester break will appear in this semester's marksheet								
MC-OE	OEC01 ^{\$}	Collaborative Inter-Institute Studies	As per course	4	125	-	-	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESA= End Semester Examination

^{\$} For Collaborative Inter-Institute Studies: Collaboration with other reputed institutes equivalent to 4 credits is recommended to be done by learner during second year inter semester break (i.e. summer break between semester 4 and semester 5).

NOTE: As per Institute guidelines, the result of courses completed in inter-semester break will appear in the marksheet of the next semester.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Guidelines for Programme Elective Courses and Specialization Certificate – Refer Appendix-A

Learners are required to go through Appendix-A carefully before selecting the Programme Elective courses. Detailed guidelines regarding Programme Elective courses, specialization tracks and courses relevant to each track are given in Appendix-A.

Programme Elective -1 Courses (PEECXX)

Specialization Track Name [#]	Course		Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@40% of total marks)
	Code	Name			ISA	MSE	ESE	
Artificial Intelligence and Machine Learning (AIML)	PEEC01T	Artificial Intelligence	Theory	2	15	20	40	075
	PEEC01P	Artificial Intelligence lab	Practical	1	25	-	25	050
Data Science (DS)	PEEC02T	Advanced Database Management System	Theory	2	15	20	40	075
	PEEC02P	Advanced Database Management System Lab	Practical	1	25	-	25	050
Internet of Things (IoT)	PEEC03T	Modern Sensors for IOT	Theory	2	15	20	40	075
	PEEC03P	Modern Sensors for IOT Lab	Practical	1	25	-	25	050
VLSI Design	PEEC04T	Digital System Design	Theory	2	15	20	40	075
	PEEC04P	Digital System Design Lab	Practical	1	25	-	25	050

[#]For details of Specialization Certificate, refer Appendix-A

Guidelines for Multidisciplinary Elective Courses and Minor Degree – Refer Appendix-B (Programme Structure)

Learners are required to go through the Appendix-B carefully before selecting the Multidisciplinary Elective courses. Detailed guidelines regarding Multidisciplinary Elective courses, Minor Degree Titles and courses relevant to each MDM Title are given in Appendix-B (Programme Structure).

Multidisciplinary Minor Courses (MDM)

Specialization Track Name [#]	Course		Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@40 % of total marks)
	Code	Name			ISA	MSE	ESE	
Bioinformatics	MDMBI03	Machine Learning Applications in Bioinformatics	Theory	4	45	30	50	125
Innovation, Entrepreneurship and Venture Development	MDMIE03	Innovation Management and Scaling Startups	Theory	4	45	30	50	125
Business Development, Marketing and Finance	MDMBD03	Strategic Marketing and Business Planning	Theory	4	45	30	50	125
Robotics	MDMRB03	Intelligent Mobile Robotics	Theory	4	45	30	50	125

Guidelines for Award of Honours/Minor Degree

Before the end of Semester 5, learners are required to go through the Honours/Minor Degree Programme document carefully to opt for Honours/Minor Degree Programme. Learners willing to opt for the Honours/ Minor Degree Programme are required to satisfy the eligibility criteria stated in the document.

Third Year B. Tech. Electronics and Computer Science
Course Structure and Assessment Guidelines

Semester: VI

Course			Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@40% of total marks)
NEP-Vertical	Code	Name			ISA	MSE	ESE	
PC-PCC	PCEC10T	Operating System	Theory	2	15	20	40	075
	PCEC10P	Operating System Lab	Practical	1	25	-	25	050
PC-PCC	PCEC12T	Theory of Computer Science	Theory + Tutorial	3	40	20	40	100
PC-PCC	PCEC14T	Analog and Digital Communication	Theory	2	15	20	40	075
	PCEC14P	Analog and Digital Communication Lab	Practical	1	25	-	25	050
PC-PEC	PEECXXT	Programme Elective-2	Theory	2	15	20	40	075
	PEECXXP	Programme Elective-2 Lab	Practical	1	25	-	25	050
PC-PEC	PEECXXT	Programme Elective-3	Theory	2	15	20	40	075
	PEECXXP	Programme Elective-3 Lab	Practical	1	25	-	25	050
MC_MDM	MDM03	Professional Competency Development 3	Practical	1	50	-	-	050
ELC	PRJEC02	Project-1 (Synopsis)	Theory + Practical	2	50	-	25	075
Total Credits				18				

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESA= End Semester Examination

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Programme Elective - 2 Courses (PEECXX)

Specialization Track Name [#]	Course		Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@40% of total marks)
	Code	Name			ISA	MSE	ESE	
Artificial Intelligence and Machine Learning (AIML)	PEEC05T	Soft Computing	Theory	2	15	20	40	075
	PEEC05P	Soft Computing Lab	Practical	1	25	-	25	050
Data Science (DA)	PEEC06T	Data Warehousing and Mining	Theory	2	15	20	40	075
	PEEC06P	Data Warehousing and Mining Lab	Practical	1	25	-	25	050
Internet of Things (IoT)	PEEC07T	Principles of IOT	Theory	2	15	20	40	075
	PEEC07P	Principles of IOT Lab	Practical	1	25	-	25	050
Very Large- Scale Integration (VLSI)	PEEC08T	Advanced VLSI Design and Technology	Theory	2	15	20	40	075
	PEEC08P	Advanced VLSI Design and Technology Lab	Practical	1	25	-	25	050

[#]For details of Specialization Certificate, refer Appendix-A

Programme Elective - 3 Courses (PEECXX)

Specialization Track Name [#]	Course		Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@40% of total marks)
	Code	Name			ISA	MSE	ESE	
Artificial Intelligence and Machine Learning (AIML)	PEEC09T	Machine Learning	Theory	2	15	20	40	075
	PEEC09P	Machine Learning Lab	Practical	1	25	-	25	050
Data Science (DS)	PEEC10T	Probabilistic Graphical Models	Theory	2	15	20	40	075
	PEEC10P	Probabilistic Graphical Models Lab	Practical	1	25	-	25	050
Internet of Things (IoT)	PEEC11T	Embedded System Design with tiny OS	Theory	2	15	20	40	075
	PEEC11P	Embedded System Design with tiny OS Lab	Practical	1	25	-	25	050
VLSI Design	PEEC12T	Analog IC Design	Theory	2	15	20	40	075
	PEEC12P	Analog IC Design Lab	Practical	1	25	-	25	050

[#]For details of Specialization Certificate, refer Appendix-A

Multidisciplinary Minor Courses (MDM)

Specialization Track Name [#]	Course		Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@40% of total marks)
	Code	Name			ISA	MSE	ESE	
For all Tracks	MDM03	Professional Competency Development 3	Practical	1	50	-	-	050

Detailed Syllabus of Third Year Semester - V

Course Name: Basic VLSI Design

Course Code: PCEC08T

NEP Vertical Basket: PC_PCC

Preamble:

Digital VLSI Design is the art and science of integrating millions to billions of transistors on a single chip to create powerful, compact, and energy-efficient digital circuits. At the heart of this discipline is the mastery of digital logic, enabling the creation of microprocessors, memory units, and diverse integrated circuits that underpin modern computing devices. The landscape of Digital VLSI Design is marked by a delicate balance between intricate circuitry and the imperative to minimize physical footprint. It plays a pivotal role not only in traditional computing but also in propelling innovations in emerging fields like artificial intelligence, machine learning, and the Internet of Things. This course provides an overview of the techniques and challenges such as shrinking transistor sizes, noise resilience, and power optimization.

Pre-requisite:

- Digital Electronics
- Electronic Devices and Circuits
- Computer Organization and Architecture

Course Objectives:

- To understand VLSI Design flow and technology trends.
- To realize MOS based circuits using different design styles.
- To study semiconductor memories using MOS logic.
- To study adder, multiplier, and shifter circuits for realizing data path design.

Course Outcomes:

After successful completion of the course students will be able to:

CO1: Demonstrate a clear understanding of VLSI Design flow, technology trends, scaling and MOSFET models.

CO2: Design and analyze MOS based inverters.

CO3: Apply design styles for realization of Combinational and Sequential Circuits.

CO4: Understand various semiconductor memories using MOS logic.

CO5: Design adder, multiplier and shifter circuits using MOS logic.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	075

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Unit No.	Contents	Hrs.
1		MOS Physics and MOSFET Scaling	05
	1.1	MOS structure and MOS Capacitance, Region of Operation of MOS (Accumulation, Depletion, and Inversion), Threshold Voltage, Effect of Body Bias	
	1.2	Region of operation of MOSFETS, Drain Current Equation of MOSFET, Parasitic capacitances in MOSFET	
	1.3	MOSFET Scaling: Constant Voltage and Constant Field, Effect of Scaling on Device parameters. Short Channel Effect: Channel Length Modulation, sub-threshold conduction, hot electron effect and velocity saturation.	
2		MOSFET Inverters	07
	2.1	Introduction to MOS inverters: Active and passive load nMOS inverters, CMOS inverter and their comparison.	
	2.2	Static & Dynamic Analysis of Resistive load and CMOS Inverter: Calculation of critical voltages, noise margins, rise time, fall time, propagation delay and power dissipation. Design of CMOS inverter.	
3		Combinational and Sequential Circuit Realization	07
	3.1	Static CMOS, Analysis and design of 2-I/P NAND, 2-I/P NOR and complex Boolean function realization using equivalent CMOS inverter for simultaneous switching	
	3.2	Basic gates and MUX realization using pass transistor and transmission gate logic Pseudo NMOS design styles, C^2 MOS, Dynamic, Domino, NORA and Zipper CMOS design styles.	
	3.3	SR Latch, JK FF, D FF, 1 Bit Shift Register realization using CMOS logic	
4		Semiconductor Memories	06
	4.1	SRAM: 6T SRAM operation, design strategy, read/write circuits, sense amplifier	
	4.2	DRAM: 1T & 3T DRAM, operation modes, leakage currents, refresh operation, physical design.	
	4.3	ROM Array: NAND and NOR based ROM array	
	4.4	Non-volatile read/write memories: Programming techniques for flash memory, Introduction to advances in non-volatile memories: MRAM, ReRAM	
5		Data Path Design	05
	5.1	Adder: Ripple Carry Adder, Carry Look Ahead (CLA) adder, Carry Generation circuit using MODL, Manchester carry chain. High-speed adders: carry skip, carry select, and carry save	
	5.2	Multipliers and shifter: Array multiplier and barrel shifter	
Total			30

Third Year Scheme & Syllabus (R-2024) Bachelor of Technology (B.Tech.)
Electronics and Computer Science

Textbooks:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	CMOS Digital Integrated Circuits Analysis and Design	Sung-Mo Kang and Yusuf Leblebici,	Tata McGraw Hill	Revised 4 th Edition	1,2,3,4,5
2	Introduction to VLSI Circuits and Systems	John P. Uyemura	Wiley India Pvt. Ltd.	Revised 4 th Edition	3,4,5

Reference Books:

Sr. No	Text Book Titles	Author/s	Publisher	Edition	Module Nos.
1	Digital Integrated Circuits: A Design Perspective	Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic	Pearson Education	2 nd	2,3,4,5
2	Basic VLSI Design	Douglas A Pucknell, Kamran Eshraghian,	Prentice Hall of India Private Ltd.	3 rd	1,2,3,4,5
3	Logical Effort: Designing Fast CMOS Circuits	Ivan Sutherland and Bob Sproull,	The Morgan Kaufmann Series in Computer Architecture and Design	4 th	2
4	Basics of CMOS Cell Design	Etienne Sicard and Sonia Delmas Bendhia	Tata McGraw Hill	4 th	1,2,3,4,5
5	CMOS VLSI Design: A Circuits and Systems Perspective	Neil H. E. Weste, David Harris and Ayan Banerjee,	Pearson Education	5 th	1,2,3,4,5
6	Analysis and Design of Digital Integrated Circuits	David Hodges, Horace Jackson, Resve Saleh.	McGraw-Hill, Inc.	3 rd	1,2,3,4,5
7	Advanced Semiconductor Memories: Architectures, Designs, and Applications	Ashok K. Sharma,	Wiley Publication	4 th	4
8	Magnetic Memory Technology: Spin-Transfer-Torque MRAM and Beyond	Denny D.Tang, Chi-Feng Pai,	Wiley online Library	2 nd	4
9	Resistive Switching: From Fundamentals of Nanoionic Redox Processes to Memristive Device Applications.	Daniele Ielmini, Rainer Waser,	Wiley online Library	3 rd	4

Course Name: Basic VLSI Design Lab

Course Code: PCEC08P

NEP Vertical Basket: PC_PCC

Preamble:

Digital VLSI Design is the art and science of integrating millions to billions of transistors on a single chip to create powerful, compact, and energy-efficient digital circuits. At the heart of this discipline is the mastery of digital logic, enabling the creation of microprocessors, memory units, and diverse integrated circuits that underpin modern computing devices. The landscape of Digital VLSI Design is marked by a delicate balance between intricate circuitry and the imperative to minimize physical footprint. It plays a pivotal role not only in traditional computing but also in propelling innovations in emerging fields like artificial intelligence, machine learning, and the Internet of Things. This course provides an overview of the techniques and challenges such as shrinking transistor sizes, noise resilience, and power optimization.

Pre-requisite:

- Digital Electronics
- Electronic Devices and Circuits
- Computer Organization and Architecture

Course Objectives:

- To understand VLSI Design flow and technology trends.
- To realize MOS based circuits using different design styles.
- To study semiconductor memories using MOS logic.
- To study adder, multiplier, and shifter circuits for realizing data path design.

Course Outcomes:

After successful completion of the course students will be able to:

CO1: Demonstrate a clear understanding of VLSI Design flow, technology trends, scaling and MOSFET models.

CO2: Design and analyze MOS based inverters.

CO3: Apply design styles for realization of Combinational and Sequential Circuits.

CO4: Understand various semiconductor memories using MOS logic.

CO5: Design adder, multiplier and shifter circuits using MOS logic.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Practical	25	-	25	50

Third Year Scheme & Syllabus (R-2024) Bachelor of Technology (B.Tech.)
Electronics and Computer Science

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Suggested list of Practicals:

Practical No.	Module No.	Suggested list of Experiments	Topics to be highlighted	CO Map
1	1	To observe the effect of scaling on the characteristics of various MOSFET's	See the effect of Constant voltage and constant field Scaling	CO1
2	2	Design and Simulation to Symmetric and Non-Symmetric CMOS Inverter	How to control the inverter threshold	CO2
3	2	Comparison of different inverters based on Critical Parameter, timing parameters and Noise margins	Comparison of various types of inverters	CO2
4	2	Design and Implementation of Equivalent inverter for any CMOS logic function.	Concept of Equivalent inverter and relevance to timing analysis	CO2
5	3	Comparison of Pseudo NMOS and CMOS Logic functions.	Pseudo NMOS Logics	CO3
6	3	Comparison of dynamic and CMOS logic functions	Dynamic Logics	CO3
7	3	Comparison of domino and CMOS logic functions	Implementation of Uncomplemented functions	CO3
8	3	Implementation of functions using NORA and Zipper CMOS	Zipper CMOS	CO3
9	3	Implementation of Logic functions using NMOS, PMOS and Pass transistor logic	Change in voltage levels while passing a logic value	CO3
10	3	Implementation of 8:1 Mux and 1:8 Demux using NMOS, PMOS and transmission gates.	MUX and DEMUX operation using Pass transistor logic	CO3
11	4	Implementation of SRAM Cell	Read, Write and Hold operations in a DRAM	CO5
12	4	Design of NOR based and NAND Based ROM	Concept of Non-Volatile Memory	CO4
13	5	Implementation of 4-bit adder Ripple Carry Adder	Delay introduced while adding many bits	CO5
14	5	Implementation of 4- bit Carry look ahead adder with carry generation circuit using MODL	Reduction of delay during adding two binary numbers	CO5
15	5	Design of 4 x 4 Barrel shifter using NMOS transistors	Data Steering, rotate left and rotate right operations	CO5
16	1,2,3,4,5	Simulation of Complete Digital Design Flow in Cadence	Digital Design Flow using Cadence	CO1,2,3,4,5
17	1,2,3,4,5	Simulation of Complete Analog Design Flow in Cadence	Analog Design Flow using Cadence.	CO1,2,3,4,5

Course Name: Signals and Systems

Course Code: PCEC05T

NEP Vertical_Basket: PC-PCC

Preamble:

Signals play an important role in our life. Generally, a signal can be a function of time, distance, position, temperature, pressure, etc., and represents some variable of interest associated with the system. The objective of signal processing is to extract information from the signal. Signal processing is concerned with representing the signal in mathematical terms and extracting the information by carrying out algorithmic operations on the signal. Digital processing of a signal has a major advantage over analog techniques.

Pre-requisite:

Engineering Mathematics 1,2,3 & ECA

Course Objectives:

- To introduce the mathematical concepts of continuous and discrete time signals and systems.
- To acquaint the students with various time domain and frequency domain methods for analysis of signals and systems.
- To introduce Fourier domain analysis of signals and systems and their efficient implementation.
- To expose students to various design techniques for FIR/IIR filters.

Course Outcomes:

After successful completion of the course students will be able to:

CO1: Identify and differentiate between continuous and discrete time signals and systems.

CO2: Develop input output relationship for LTI systems.

CO3: Analyze LTI CT and DT system in frequency domain.

CO4: Analyze discrete time systems in frequency domain using Discrete Fourier Transform.

CO5: Design IIR digital filters to meet given filter specifications.

CO6: Design FIR digital filters to meet given filter specifications.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	075

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a

panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Unit No.	Contents	No. of Hours
1	1.1	Classification of Signals and operations of signals classification of CT and DT signals	06
	1.2	operations on the independent and dependent variables	
	1.3	Sampling and reconstruction, aliasing effect	
2	2.1	Classification of system and analysis in time domain classification of CT and DT systems	06
	2.2	Properties of LTI systems, impulse, and step response	
	2.3	Analysis of CT LTI systems using convolution integral and DT LTI systems using convolution sum. Properties convolution	
	2.4	Circular convolution	
3	3.1	Frequency Domain Analysis of Continuous Time System and DT system Pole and zero plot in S domain and Z domain	04
	3.2	Analysis and characterization of CT LTI system using Laplace transform: impulse and step response, causality, stability of CT system	
	3.3	Analysis and characterization of DT LTI system using Z transform: impulse and step response, causality and stability of DT LTI system	
4		Discrete Fourier Transform and Fast Fourier Transform	06
	4.1	Definition and Properties of DFT, IDFT, circular convolution of sequences using DFT and IDFT, Relation between Z-transform and DFT, Filtering of long data sequences using Overlap Save and Overlap Add Method	
	4.2	Fast Fourier transforms (FFT), Radix-2 decimation in time and decimation in frequency FFT algorithms, Inverse FFT	
5		Design of Infinite Impulse Response (IIR) Filters	04
	5.1	Analog filter approximations: Butterworth, Chebyshev	
	5.2	Mapping of S-plane to Z-plane: Impulse invariance method, Bilinear transformation method, Design of IIR digital filters from analog filters with examples (Butterworth, Chebyshev)	
6		Design of Finite Impulse Response (FIR) Filters	04
	6.1	Characteristics of FIR digital filters, Minimum Phase, Maximum Phase, Mixed Phase and Linear Phase Filters, Frequency response and location of zeros for linear phase FIR filters	
	6.2	Effect of truncation on ideal filter impulse response, Design of FIR filters using window techniques (Rectangular, Hamming, Hanning, Blackmann, Bartlett)	
		Total	30

Textbooks:

1. Signal processing and linear systems: Lathi, Bhagwandas Pannalal, and Roger A. Green. New York: Oxford University Press, 1998.
2. Signals & Systems: Kani, A. Nagoor.. Tata McGraw-Hill Education, 2010.
3. Signals and Systems: Tarun Kumar Rawat, Oxford University, 1st Edition
4. Digital Signal Processing: Proakis J., Manolakis D, Pearson Education, 4th Edition
5. Tarun Kumar Rawat, "*Digital Signal Processing*", Oxford University Press, 2015

Reference Books:

1. Oppenheim A., Schafer R., Buck J., "*Discrete Time Signal Processing*", 2nd Edition, Pearson Education
2. Johnson J. R., "*Introduction to Digital Signal Processing*", Prentice Hall
3. Emmanuel C. Ifeachor, Barrie W. Jervis, "*Digital Signal Processing: A Practical Approach*", Pearson Education, 2001
4. Sanjit K. Mitra, Digital Signal Processing – A Computer Based Approach – edition 4e McGraw Hill Education (India) Private Limited
5. B. Venkata Ramani and M. Bhaskar, "*Digital Signal Processors, Architecture, Programming and Applications*", Tata McGraw Hill, 2011.

Course Name: Signals & Systems Lab

Course Code: PCEC05P

NEP Vertical_Basket: PC-PCC

Preamble:

Signals play an important role in our life. Generally, a signal can be a function of time, distance, position, temperature, pressure etc., and represents some variable of interest associated with the system. The objective of signal processing is to extract information from the signal. Signal processing is concerned with representing the signal in mathematical terms and extracting the information by carrying out algorithmic operations on the signal. Digital processing of a signal has a major advantage over analog techniques.

Pre-requisite:

Engineering Mathematics 1,2,3 & ECA

Course Objectives:

- The primary objective of this course is to provide a thorough understanding and analysis of signals and systems using MATLAB.
- To implement Linear and Circular Convolution
- To implement FIR and IIR filters

Course Outcomes:

Students will be able to:

CO1: Understand the basics of MATLAB syntax, functions, and programming.

CO2: Generate and characterize various continuous and discrete-time signals and perform basic operations.

CO3: Design and analyze linear time-invariant (LTI) systems and compute their response.

CO4: Analyze the spectral characteristics of signals using Fourier analysis, Laplace Transform, DFT, and Z transform.

CO5: To design FIR and IIR filters.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Practical	25	-	25	050

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by

a panel constituted at institute level and published to the learners before the commencement of the semester.

ISA:

At least 10 experiments covering entire syllabus of EC06T (Signals & System) should be set to have well predefined inference and conclusion. The experiments should be student centric, and attempt should be made to make experiments more meaningful, interesting. Simulation experiments are also encouraged. Experiment must be graded from time to time. Practical and Oral exam will be based on the entire syllabus.

Suggested List of Experiments is provided, however Instructor is free to design own experiments as per the guidelines

Suggested list of Experiments

Sr. No.	Experiment Title
1	Generation of Signals using MATLAB/Python
2	Find Unit impulse response of LTI system in time domain
3	Find LTI system output for given input signal (Linear Convolution)
4	Find LTI system output for given periodic input signal (Circular Convolution)
5	Compute DFT for given signal and plot magnitude and phase plot.
6	Computation of circular convolution using DFT and IDFT approach
7	Compute filter output data for a long sequence using overlap add method
8	IIR LPF Butterworth filter design using IIT /BLT technique
9	IIR LPF Chebyshev filter design using BLT/ IIT technique
10	Design of FIR filter using hamming and Hanning window
10	Compute filter output data for a long sequence using overlap save method
11	Find DFT of a sequence using virtual lab
12	Select Music Signal. Separation of high frequency and low frequency data and play it separately. 1. Plot frequency plot for the music. 2. Identify cutoff frequency for LPF and HPF. 3. Design LPF and HPF filter. 4. Apply the filter to original music and play output separately. (PBL)

Course Name: Microcontroller and Applications

Course Code: PCEC09T

NEP Vertical Basket: PC_PCC

Preamble:

A professional in any field of computing should be able to appreciate the difference between Microprocessor and Microcontroller and should be able to understand the fundamental units of a Microcontroller. A knowledge of programming in assembly language as well as embedded C for microcontroller-based systems is a must. The course provides the in-depth knowledge of Microcontroller based systems and programming with it.

Pre-requisite:

Digital Electronics
Computer Organization and Architecture
Fundamental concepts of processing

Course Objectives:

- To introduce the learner to the basic difference between Microprocessor and Microcontroller and design Microcontroller based systems
- To introduce the learner to the concept of assembly language programming
- To introduce the learner to the concept of embedded C programming

Course Outcomes:

After successful completion of the course students will be able to:

CO1: Understand fundamental concepts of microcontrollers

CO2: Explain different building blocks of microcontrollers

CO3: Apply the knowledge of instruction set of microcontroller to develop assembly language and embedded C programs

CO4: Analyze the performance of a microcontroller by interfacing different peripherals and writing simple applications

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	075

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose a revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	8051 Microcontroller Architecture	Introduction to the concepts of Microprocessors and Microcontrollers Overview of various available Microcontrollers Applications of Microcontrollers 8051 Architecture	4
2	8051 Internal Hardware	Memory organization Timers/Counters and programming Serial port and programming Interrupts and Interrupt control Power Saving modes	6
3	8051 Assembly language programming	Addressing modes of 8051 Instruction Set: Data transfer instructions, Arithmetic instructions, Logical instructions, Bit Processing, Branching instructions, Assembler directives	6
4	8051 programming in Embedded C	Embedded C-programming concepts: Data types, Modifiers, Qualifiers, Functions, Macros, Interrupt service routines Embedded C programming for 8051 (Timers/Counters, Serial port and Interrupts)	6
5	8051 Interfacing –Part 1	Display interfacing: 7-segment LED display, 16x2 generic alphanumeric LCD display Keyboard interfacing: 4x4 matrix keyboard	4
6	8051 Interfacing –Part 2	Analog devices interfacing: 8-bit ADC, 8-bit DAC, temperature sensor (LM35) Motor interfacing: Relay, DC motor (speed control using PWM), Stepper motor and Servo motor	4
Total			30

Text Books:

1. M. A. Mazidi, J., C. Mazidi, Rolin, D. McKinlay, "The 8051 Microcontroller and Embedded Systems Using Assembly and C", Pearson Education, 2nd edition.
2. Kenneth J. Ayala, "The 8051 Microcontroller", Cengage Learning India Pvt. Ltd, 3rd edition.

Reference Books:

1. Raj Kamal, "Microcontrollers: Architecture, Programming, Interfacing and System Design", Pearson Education, 2009, 2nd edition.
2. Manish K Patel, "The 8051 Microcontroller Based Embedded Systems", McGraw Hill, 2014, 3rd edition.
3. Ajay V Deshmukh, "Microcontroller Theory and Applications", Tata McGraw Hill, 2017, 3rd edition.

Course Name: Microcontroller and Applications Lab

Course Code: PCEC09P

NEP Vertical Basket: PC_PCC

Preamble:

A professional in any field of computing should be able to appreciate the difference between Microprocessor and Microcontroller and should be able to understand the fundamental units of a Microcontroller. A knowledge of programming in assembly language as well as embedded C for microcontroller-based systems is a must. The course provides the in-depth knowledge of Microcontroller based systems and programming with it.

Pre-requisite:

Computer Organization and Architecture
Fundamentals of C programming

Course Objectives:

- To introduce learners with basic principles about microcontroller architecture, machine language, and low-level programming.
- To introduce learners with enough assembly language and embedded C to enhance their knowledge of today's most widely used microcomputer family.
- To Improving learners systems programming skills through programming exercises carried out by students.

Course Outcomes:

After successful completion of the course students will be able to:

CO1: Understand instruction set/format of a microcontroller.

CO2: Understand concept of assembly language and embedded C programming.

CO3: Develop assembly language and embedded C program for simple applications.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Practical	25	-	25	50

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose a revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Suggested List of Experiments

Sr No.	Suggested Experiments
1.	Develop assembly language code to add, subtract, multiply, divide, two, 8-bit numbers which will occupy minimum program memory space.
2.	Develop assembly language code to convert the input from keyboard to the format which can be used for processing internally.
3.	Given a bucket of ten, 8-bit numbers, develop assembly language code to find out smallest and largest element out of the bucket.
4.	Given an 8-bit numbers, develop assembly language code to check whether it is odd or even and to find out whether it has odd or even parity.
5.	It is required to glow the LED connected on P1.0 for some time and switch it OFF for the same time and repeat this for infinite time, develop the assembly code for the same.
6.	Develop assembly and C language code to display rolling pattern from left to right and right to left on the LEDs connected to PORT 1.
7.	Interface a 4 x 4 matrix type of keyboard with 8051. Develop assembly and C language code to detect the key closure.
8.	Interface a 4-phase stepper motor with 8051. Develop assembly and C language code to rotate the stepper motor clockwise for some time and anti-clockwise for the same time continuously.
9.	Interface a common cathode type of 7-segment display with 8051. Develop assembly and C language code to demonstrate Up/Down counting continuously.
10.	Interface 8-bit DAC, 0808 with 8051. Develop assembly and C language code to generate continuous rectangular wave with 1 kHz frequency and 40% duty cycle.

Textbooks:

1. M. A. Mazidi, J. C. Mazidi, Rolin, D. McKinlay, "The 8051 Microcontroller and Embedded Systems Using Assembly and C", Pearson Education, 2nd edition.
2. Kenneth J. Ayala, "The 8051 Microcontroller", Cengage Learning India Pvt. Ltd, 3rd edition.

Reference Books:

1. Raj Kamal, "Microcontrollers: Architecture, Programming, Interfacing and System Design", Pearson Education, 2009, 2nd edition.
2. Manish K Patel, "The 8051 Microcontroller Based Embedded Systems", McGraw Hill, 2014, 3rd edition.
3. Ajay V Deshmukh, "Microcontroller Theory and Applications", Tata McGraw Hill, 2017, 3rd edition.

Course Name: Analysis of Algorithms

Course Code: PCEC11T

NEP Vertical Basket: PC_PCC

Preamble:

The course covers the fundamental principles and techniques used in designing and analyzing algorithms. Students will learn how to analyze the performance of algorithms, measure their efficiency, and compare different algorithms based on their time and space complexity. The course is designed for students with a solid understanding of programming and data structures. By the end of the course, students will have a deep understanding of the principles of algorithm design and analysis and will be equipped with the tools and techniques necessary to develop efficient algorithms for a wide range of computational problems.

Pre-requisites:

Engineering Mathematics-III – Sem 3

Data Structures – Sem 3

Course Objectives:

- To provide a deep understanding of algorithmic design and analysis techniques that enable the development of efficient and effective algorithms for solving computational problems.
- To develop a strong foundation in the theory of algorithms, including concepts such as time and space complexity, algorithmic paradigms, data structures, graph algorithms, sorting and searching, and dynamic programming.
- To equip students with the tools and techniques necessary to compare and evaluate the performance of different algorithms and choose the best algorithm for a given problem.
- To provide students with the knowledge and skills required for a successful career in software development, data analysis, and other fields that require strong analytical and problem-solving abilities

Course Outcomes:

Learner will be able to:

CO1: Analyze the time and space complexity of algorithms.

CO2: Apply and Analyze Divide and Conquer strategy to solve given problems.

CO3: Apply and Analyze Greedy strategy to solve given problems.

CO3: Apply and Analyze Dynamic Programming strategy to solve given problems.

CO4: Apply and Analyze Backtracking, Branch and Bound strategy to find solution for the given problems.

CO5: Classify a problem as computationally tractable or intractable and discuss strategies to address intractability.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	75

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction to Algorithm Analysis	Performance analysis: Space, and Time complexity, Growth of function. Asymptotic Notations: Big-Oh, Omega Theta notation. Analysis of selection sort, insertion sort and Naïve String- Matching Algorithm. Recurrences: The substitution method, Recursion tree method, Master method.	8
2	Divide and Conquer Approach	General method, Analysis of Merge sort and Quick sort, Finding minimum and maximum algorithms and their Analysis, Analysis of Binary search.	4
3	Greedy Method Approach	General Method, Analysis of Minimum cost spanning trees: Kruskal and Prim's algorithm, Single source shortest path: Analysis of Dijkstra's Algorithm, Fractional Knapsack Problem and Job Sequencing with Deadlines	6
4	Dynamic Programming Approach	General Method, Finding nth term in Fibonacci series, Single Source Shortest Path: Bellman Ford Algorithm All Pair Shortest Path: Floyd Warshall's Algorithm, Longest Common Subsequence, 0/1 Knapsack Problem, Matrix Chain Multiplication and Sum of Subset Problem.	7
5	Backtracking and Branch	General Method, Backtracking: N-queen problem, Graph Coloring. Branch and Bound: 15 Puzzle problem, Travelling	3

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Module No.	Module Name	Content	No. of Hours
	and Bound	Salesperson Problem	
6	Introduction to Complexity Theory	The class P and NP. Polynomial reduction. NP-Complete Problems. NP-Hard Problems	2
Total			30

Text Books:

1. T. H. Cormen, C.E. Leiserson, R. L. Rivest, and C. Stein, "Introduction to algorithms", 2nd Edition, PHI Publication 2005.
2. Jon Kleinberg, Eva Tardos "Algorithm Design", Pearson Education.
3. Ellis Horowitz, Sartaj Sahni, S. Rajsekar. "Fundamentals of computer algorithms" University Press.

Reference Books:

1. Sanjoy Dasgupta, Christos Papadimitriou, Umesh Vazirani, "Algorithms", Tata McGraw-Hill Edition.
2. S. K. Basu, "Design Methods and Analysis of Algorithm", PHI.

Course Name: Analysis of Algorithms Lab

Course Code: PCEC11P

NEP Vertical Basket: PC_PCC

Preamble:

The course covers the fundamental principles and techniques used in designing and analyzing algorithms. Students will learn how to analyze the performance of algorithms, measure their efficiency, and compare different algorithms based on their time and space complexity. The course is designed for students with a solid understanding of programming and data structures. By the end of the course, students will have a deep understanding of the principles of algorithm design and analysis and will be equipped with the tools and techniques necessary to develop efficient algorithms for a wide range of computational problems.

Pre-requisites:

Engineering Mathematics-III
Data Structures Lab

Course Objectives:

- To introduce the methods of designing and analyzing algorithms.
- Design and implement efficient algorithms for a specified application.
- Strengthen the ability to identify and apply suitable algorithms for the given real-world problem.
- Analyze worst-case running time of algorithms and understand fundamental algorithmic problems.

Course Outcomes:

At the end of the course, the students will be able to

CO1: Implement the algorithms using different approaches.

CO2: Analyze the complexities of various algorithms.

CO3: Apply and Analyze Greedy strategy to solve given problems.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	25	--	25	50

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Suggested List of Practical's:

Sr No.	Suggested Topic(s)
1.	Introduction: Selection sort, Insertion sort
2.	Divide and Conquer Approach: Finding Minimum and Maximum, Merge sort, Quick sort, Binary search
3.	Greedy Method Approach: Single source shortest path- Dijkstra Fractional Knapsack problem Job sequencing with deadlines Minimum cost spanning trees-Kruskal and Prim's algorithm
4.	Dynamic Programming Approach: Single source shortest path- Bellman Ford All pair shortest path- Floyd Warshall 0/1 knapsack Longest common subsequence
5.	Backtracking: N-queen problem Graph coloring

Text Books:

1. T. H. Cormen, C.E. Leiserson, R. L. Rivest, and C. Stein, "Introduction to algorithms", 2nd Edition, PHI Publication 2005.
2. Jon Kleinberg, Eva Tardos "Algorithm Design", Pearson Education.
3. Ellis Horowitz, Sartaj Sahni, S. Rajsekar. "Fundamentals of computer algorithms" University Press.

Reference Books:

1. Sanjoy Dasgupta, Christos Papadimitriou, Umesh Vazirani, "Algorithms", Tata McGraw-Hill Edition.
2. S. K. Basu, "Design Methods and Analysis of Algorithm", PHI.

Course Name: Mini Project-I

Course Code: PRJ01

NEP Vertical Basket: ELC

Preamble:

Students will be acquainted with the process of identifying the needs and converting it into the problem. Third year students will be familiarized with the process of solving the problem in a group and applying basic engineering fundamentals to attempt solutions to the problems. This will inculcate the process of self-learning and research.

Pre-requisites:

All subjects they learned till TE and beyond.

Course Objectives:

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To familiarize the process of solving the problem in a group.
3. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4. To inculcate the process of self-learning and research.

Course Outcomes:

Learner will be able to:

CO1: Identify problems based on societal /research needs and apply Knowledge and skill to solve societal problems in a group.

CO2: Develop interpersonal skills to work as member of a group or leader and Excel in written and oral communication.

CO3: Draw the proper inferences from available results through theoretical/ experimental/simulations and analyze the impact of solutions in societal and environmental context for sustainable development

CO4: Use standard norms of engineering practices

CO5: Demonstrate capabilities of self-learning in a group, which leads to lifelong learning

CO6: Demonstrate project management principles during project work.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	4	-	2

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Practical	25	-	50	75

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall decide her/his assessment methodology based on the course's nature. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Guidelines for Mini Project:

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students shall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality to be carried out in two semesters by all the groups of the students. Mini Project 2 in semesters V and VI.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

Internal Assessment:

- The review/ progress monitoring committee shall be constituted by head of department. The progress of mini project to be evaluated on continuous basis, minimum two reviews during the semester.

1. Review 1: First review shall be for finalization of problem and proposed solution
 2. Review 2: Second review shall be for implementation and testing of solution.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
 - Distribution of internal assessment marks for minor project shall be as below:
 1. Marks awarded by guide/supervisor based on log book: 10
 2. Marks awarded by review committee: 10
 3. Quality of Project report: 05

Minor Project shall be assessed based on following criteria:

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness and Societal impact
6. Full functioning of working model as per stated requirements
7. Effective use of skill sets
8. Effective use of standard engineering norms
9. Contribution of an individual's as member or leader
10. Clarity in written and oral communication In case of minor project-I all criteria in generic may be considered for evaluation of performance of students in mini project.

End semester examination assessment:

- Report should be prepared as per the guidelines issued by the department.
- Minor Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organizations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Detailed Syllabus of Multidisciplinary Minor Courses

Course Name: Strategic Marketing and Business Planning

Course Code: MDMBD03

NEP Vertical_Basket: MDC_MDM

Preamble:

The objective of this course is to advance the student's knowledge in planning and managing a business in the tech sector with an emphasis on marketing strategy, branding, and market expansion.

Pre-requisites:

Introduction to Business Development and Marketing Principles, Financial Basics for Engineers and Technopreneurs

Course Objectives:

- Create effective marketing and branding strategies for engineering products.
- Explore B2B and B2C models.
- Learn to write a business plan.
- Evaluate market entry and scale-up strategies.

Course Outcomes:

Students will be able to:

CO1: Draft a business plan with marketing, operations and financial sections.

CO2: Create a brand positioning strategy for a tech product.

CO3: Compare different go-to-market models and digital strategies.

CO4: Design a simple customer acquisition funnel

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	20	30	50	100

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Strategic Marketing	Market analysis techniques, segmentation and targeting, positioning strategy, BCG Matrix, SWOT analysis.	9
2	Branding and Identity	Elements of branding, creating brand equity, storytelling, brand positioning strategy for tech startups.	7
3	Market Entry Strategy	Domestic vs international markets, pricing models, product launch strategy, sales forecasting.	7
4	Business Planning	Components of a business plan including executive summary, marketing plan, operations, HR, and financial plan.	10
5	Customer Acquisition	Customer acquisition cost (CAC), sales funnels, CRM basics, online and offline channel strategy.	6
6	Technology Markets	Market behavior and innovation diffusion in electronics and telecommunication sectors. Case studies.	6
Total			45

PO Mapping by Module:

- Module 1: PO3, PO5
- Module 2: PO6, PO10
- Module 3: PO7, PO11
- Module 4: PO11, PO12
- Module 5: PO3, PO9
- Module 6: PO2, PO6

Textbooks:

1. Marketing for Entrepreneurs- Frederick Crane, Sage Publications

Reference Books:

1. How to Build a Startup - Udacity Free Course

Course Name: Strategic Marketing and Business Planning Tutorial

Course Code: MDMBD03

NEP Vertical_Basket: MDC_MDM

Preamble:

The objective of this course is to advance the student's knowledge in planning and managing a business in the tech sector with an emphasis on marketing strategy, branding, and market expansion.

Pre-requisites:

Introduction to Business Development and Marketing Principles, Financial Basics for Engineers and Technopreneurs

Course Objectives:

- Create effective marketing and branding strategies for engineering products.
- Explore B2B and B2C models.
- Learn to write a business plan.
- Evaluate market entry and scale-up strategies.

Course Outcomes:

Student will be able to:

CO1: Draft a business plan with marketing, operations and financial sections.

CO2: Create a brand positioning strategy for a tech product.

CO3: Compare different go-to-market models and digital strategies.

CO4: Design a simple customer acquisition funnel

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Tutorial	Theory	Tutorial
-	1	-	1

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Tutorial	25	-	-	25

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Suggested list of Tutorial:

1. Strategic analysis of a local brand (2 hrs)
2. Develop a mock business plan (2 hrs) 3
3. Brand storytelling and pitch creation (2 hrs)
4. Marketing channel mapping (2 hrs)
5. Business simulation case review (2 hrs)
6. Business pitch drill (3 hrs)
7. Analysis of brand elements of any start up tech brand of choice/ Plan for international market entry of a tech brand (2 hrs)

Textbooks:

1. Marketing for Entrepreneurs- Frederick Crane, Sage Publications

Reference Books:

1. How to Build a Startup - Udacity Free Course

Course Title: Innovation Management and Scaling Startups

Course Code: MDMIE03

Vertical/ Sub-Vertical: MDM

K-S-A Mapping: Knowledge and Skills

Pre-requisite required: MDMIE01, MDMIE02

Pre-requisite for: NIL

Recommended Semester: 5

Preamble:

Enable engineering students to identify real problems, develop technically feasible solutions, validate them with users, and create a credible plan to scale the solution from prototype to pilot to early market deployment.

This course is designed to help students understand how startups and innovation-driven organisations move beyond the early idea and planning stage into product-market fit, growth, scale, and long-term sustainability. Building on the concepts introduced in Foundations of Innovation and Entrepreneurship and Startup Planning and Development, the course focuses on managing innovation, developing scalable products, building growth strategies, creating partnerships, using emerging technologies responsibly, and preparing ventures for expansion.

The course combines global innovation frameworks with practical startup scaling methods used by founders, product teams, investors, and innovation leaders. Students will explore how organisations manage innovation portfolios, use agile and AI-enabled product development practices, measure growth through startup metrics, scale operations and teams, build strategic partnerships, and address responsible innovation, sustainability, data privacy, and AI governance.

The teaching approach is case-based and application-oriented, with emphasis on real-world examples, technology-led ventures, group activities, startup growth analysis, and scale-up strategy development.

Pre-requisites: MDMIE01 & MDMIE02

Course Objectives:

- To introduce students to innovation management and startup scale-up.
- To understanding of types of business innovation
- To understand product development stages and resource requirement
- To understand build awareness, product / company compliance
- To enable students to prepare an innovation - driven start up.

Course Outcomes:

Students will be able to:

CO1: Understand the fundamental of innovation, design thinking and innovation

CO2: Learn types of business innovation

CO3: Industrial product development stages and innovation in scaling

CO4: Scaling innovation and success measurement

Course Scheme:

Course Code	Contact Hours		Credits Assigned	
	Theory	Tutorial	Theory	Tutorial
MDMIE01	3	1	3	1

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	45	30	50	125

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Fundamental of Innovation	Fundamental of innovation: Introduction to Innovation, Types of Innovation: Product, Process, Business Model, and Social Innovation, Innovation vs. Invention. Innovation lifecycle. Innovation Ecosystem, Characteristics of Innovative Organizations. Design Thinking and Problem Identification Understanding User Needs, Empathy Mapping, Problem Framing Techniques, Design Thinking Process, Opportunity Identification. Creativity and Idea Generation. Creative Thinking Techniques, Brainstorming and Mind Mapping, TRIZ Methodology, Idea Screening and Prioritization, Concept Development. Role of AI in fundamental of innovation Group Assignment: understand FMCG product Innovation (Case study presentation/ Advertisement interpretation)	12
2	Types of Business Innovation	Stages of startup: Idea stage, validation stage, MVP stage, startup formation stage, early traction stage, growth stage, scaling stage, maturity stage, exit stage Incremental, disruptive, architectural, and business model innovation. Innovation lifecycle and innovation portfolio. Open innovation, co-creation, and ecosystem-based innovation. Case studies on the business innovation. Case study will be shared amongst the group. Case study interpretation, innovation and conclusion.	10
3	Product development stages and resource requirements	Product development stages. POP, POC, MVP, Marketable product, compliance (Government and product compliance). Challenges and valley of death. Product market fit, Resources requirement and preparation:	8

		Growth-stage funding and investor readiness. Basics of valuation, cap table awareness, and funding rounds. Strategic partnerships, alliances, platform thinking, and distribution partnerships. Component of ideal pitch deck, investor expectations, time management.	
4	Product scaling and innovation	Product-market fit and customer feedback loops. Product roadmap and feature prioritisation. Business model canvas innovation, growth metrics, scaling, partnerships. Case studies business innovation	8
5	Scaling innovation, strategic moves, success measurement and accounting	Responsible innovation and ethical scaling. Data driven decision, social entrepreneurship and impact-driven business models. Impact measurement. Data privacy and start up governance. Modern tool for decision making. Role of AI in scaling. AI-enabled workflows	7
Total			45

Tutorials:

- Case study analysis of Indian and global scaling startups.
- Innovation audit of an existing product, startup, or organisation.
- Product-market fit analysis using customer personas and feedback loops.
- Prototype testing workshop using no-code, low-code, or AI-assisted tools.
- Growth metrics worksheet using KPIs, OKRs, funnel metrics, retention, and revenue logic.
- AI-assisted startup scaling exercise for market research, product ideas, customer communication, and growth planning.
- Investor and partnership role-play discussion.
- Responsible AI, privacy, sustainability, and ethical scaling discussion.
- Group activity: preparing a scale-up strategy for a selected startup idea.

Textbooks:

1. Business Model Generation: Alexander Osterwalder and Yves Pigneur: Designing and innovating business models using the Business Model Canvas.
2. Zero to One: Peter Thiel: Building breakthrough innovations and creating unique market value.
3. Crossing the Chasm: Geoffrey A. Moore: Strategies for scaling technology products from early adopters to mainstream markets.
4. Blitzscaling: Reid Hoffman and Chris Yeh: Rapid scaling strategies for startups operating in highly competitive markets.
5. Blue Ocean Strategy — W. Chan Kim and Renée Mauborgne
6. The Innovator's Dilemma — Clayton Christensen

Reference Reading:

1. Reid Hoffman and Chris Yeh, Blitzscaling, Currency.
2. Alexander Osterwalder and Yves Pigneur, Business Model Generation, Wiley.
3. Steve Blank and Bob Dorf, The Startup Owner's Manual, K&S Ranch.
4. OECD/Eurostat, Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation. <https://doi.org/10.1787/9789264304604-en>
5. NIST, Artificial Intelligence Risk Management Framework (AI RMF 1.0). <https://www.nist.gov/itl/ai-risk-management-framework>

6. World Economic Forum, Future of Jobs Report 2025. <https://www.weforum.org/publications/the-future-of-jobs-report-2025/>
1. Selected case studies and reports from [Y Combinator Startup Library](#), Harvard Business Review, MIT Technology Review, NASSCOM, and Startup India.

Course Name: Machine Learning Applications in Bioinformatics

Course Code: MDMBI03

Vertical/ Sub-Vertical: MDM

K-S-A Mapping: Knowledge and Skills

Pre-requisite required: MDMBI01 (Introduction to Bioinformatics), PCIT15T (Machine Learning)

Pre-requisite for: NIL

Recommended Semester: 7

Course Scheme:

Course Code	Contact Hours		Credits Assigned	
	Theory	Practical	Theory	Practical
MDMBI03	3+1*	-	4	-

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	45	30	50	125

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Preamble:

This course introduces the integration of Machine Learning techniques with Bioinformatics for analyzing complex biological data. It covers fundamental concepts of bioinformatics, biological datasets, and essential machine learning methods including supervised, unsupervised, and deep learning approaches. The course emphasizes data preprocessing, pattern recognition, and predictive modeling in genomics, proteomics, and other omics data. It also highlights real-world applications in healthcare such as disease prediction, drug discovery, and precision medicine. The subject aims to equip students with analytical and computational skills required for modern biological and biomedical research.

Course Objectives:

- To introduce the fundamental concepts of bioinformatics and machine learning for biological data analysis.
- To enable students to apply data preprocessing, feature selection, and representation techniques on biological datasets.
- To develop the ability to apply supervised and unsupervised learning algorithms for solving bioinformatics problems.
- To provide understanding of deep learning methods and their applications in genomics, proteomics, and healthcare analytics.

Course Outcomes:

Learner will be able to:

Course Outcomes	Course Outcome Statement	Bloom's Level
CO1	Explain the fundamental concepts of bioinformatics and machine learning techniques.	Remember
CO2	Describe biological data preprocessing, feature selection, and data representation methods.	Understand
CO3	Apply supervised learning algorithms for classification and prediction in bioinformatics.	Apply
CO4	Apply clustering and pattern recognition techniques on biological datasets.	Apply
CO5	Analyze deep learning models used in sequence and structure analysis.	Analyze
CO6	Analyze machine learning applications in healthcare and bioinformatics domains.	Analyze

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours	CO's Mapped
1	Introduction to Bioinformatics and Machine Learning	Overview of bioinformatics, Biological datasets, Challenges in biological data analysis, Introduction to Artificial Intelligence and Machine Learning, Applications of ML in bioinformatics and healthcare	6	CO1
2	Data Preprocessing and Biological Data Representation	Biological data representation, Data cleaning and preprocessing, Handling missing biological data, Feature engineering and feature selection, Data normalization and scaling, Data visualization techniques, Applications such as disease prediction based on gene expression data.	7	CO2
3	Supervised Learning Techniques in Bioinformatics	Introduction to supervised learning, Regression techniques, Classification algorithms - K-Nearest Neighbours (KNN), Decision Trees, Random Forest, Support Vector Machines (SVM), Model evaluation metrics, Cross-validation and model optimization. Application such as Protein function prediction	9	CO3
4	Unsupervised Learning and Pattern Recognition	Introduction to unsupervised learning, Clustering methods - K-Means clustering, Hierarchical clustering, DBSCAN, Dimensionality reduction, Pattern recognition in omics data, Association analysis in biological datasets, Application like Protein-Protein Interactions etc.	7	CO4

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5	Deep Learning Applications in Bioinformatics	Introduction to deep learning, Artificial Neural Networks (ANN), Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), Transformers and attention mechanisms, Protein folding and structure prediction. Application like Biomedical image analysis.	8	CO5
6	Advanced Machine Learning Applications in Bioinformatics	Ensemble learning techniques, Explainable AI (XAI) in healthcare, Machine learning in genomics and precision medicine, Drug discovery and virtual screening, Biomedical signal and image analysis, AI-driven disease diagnosis, Ethical issues and bias in biomedical AI, Emerging trends in AI for bioinformatics	8	CO6
Total			45	

Textbooks:

1. P. Baldi and S. Brunak, *Bioinformatics: The Machine Learning Approach*, 2nd ed. Cambridge, MA, USA: MIT Press, 2001.
2. Goodfellow, Y. Bengio, and A. Courville, *Deep Learning*. Cambridge, MA, USA: MIT Press, 2016. Hardcover edition available.
3. M. Lesk, *Introduction to Bioinformatics*, 5th ed. Oxford, UK: Oxford University Press, 2019.

Reference Books:

1. C. M. Bishop, *Pattern Recognition and Machine Learning*. New York, NY, USA: Springer, 2006. Hardcover edition widely available.
2. T. Hastie, R. Tibshirani, and J. Friedman, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*, 2nd ed. New York, NY, USA: Springer, 2009. Hardcover edition available.
3. S. J. D. Prince, *Understanding Deep Learning*. Cambridge, MA, USA: MIT Press, 2023. Hardcover edition available.

Online Reference Material:

1. Coursera – Bioinformatics Specialization (UC San Diego) - <https://www.coursera.org/specializations/bioinformatics>
2. Scikit-learn Official Documentation - https://scikit-learn.org/stable/user_guide.html
3. DeepLearning.AI Courses - <https://www.deeplearning.ai/courses/>
4. EMBL-EBI Training Portal - https://www.ebi.ac.uk/training/?utm_source=chatgpt.com

Course Name: Intelligent Mobile Robotics

Course Code: MDMRB03

Category: Multidisciplinary Minor (MDM)

Preamble:

This course introduces the fundamentals of mobile robotics with an emphasis on navigation and path planning. Students learn how mobile robots perceive their environment, localize themselves, and plan safe and efficient paths using classical and optimization-based algorithms such as Bug methods, A*, Potential Fields, and Gradient Descent.

Course Objectives:

- To understand the kinematics, sensing, and perception principles governing mobile robot motion and environment interaction.
- To apply localization, mapping, and classical path planning algorithms for autonomous navigation.
- To design and evaluate optimization-based and intelligent path planning strategies for smooth and collision-free robot motion.

Pre-requisites:

Fundamentals of Robotics and Control (BMMDM1T)

Course Outcome: The students will be able to:

- CO1: Explain the fundamentals of mobile robots, locomotion mechanisms, and kinematic principles including wheel constraints, manoeuvrability, and motion control of mobile robotic systems. (Modules 1 & 2)
- CO2: Describe the principles of robot perception, sensor systems, uncertainty representation, and feature extraction techniques used in mobile robots. (Module 3)
- CO3: Apply localization and mapping techniques including probabilistic localization, belief representation, and map representation for determining robot position in an environment. (Module 4)
- CO4: Analyze localization-based navigation methods and autonomous map-building techniques for mobile robot navigation. (Modules 4 & 5)
- CO5: Design path planning and obstacle avoidance strategies for autonomous mobile robots using planning and reacting approaches. (Module 5)
- CO6: Evaluate navigation architectures, decomposition techniques, and modern autonomous navigation systems used in intelligent mobile robots. (Module 6)

Course Scheme:

Course Code	Contact Hours		Credits Assigned	
	Theory	Practical	Theory	Practical
MDMRB03	3	2	3	1

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory+ Tutorial	45	30	50	125

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose a revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Module Contents	No. of Hours
01	Introduction and Locomotion	Introduction to mobile robots; overview of mobile robotics; key issues in locomotion; legged mobile robots; leg configurations and stability; examples of legged locomotion; wheeled mobile robots; wheeled locomotion design space; case studies of wheeled mobile robots.	07
02	Mobile Robot Kinematics	Kinematic models and constraints; representation of robot position; forward kinematic models; wheel kinematic constraints; robot kinematic constraints; examples of robot kinematic models; mobile robot manoeuvrability; degree of mobility and steerability; robot workspace; holonomic robots; path and trajectory considerations; motion control — open loop and feedback control.	08
03	Perception	Sensors for mobile robots; sensor classification and performance; wheel and motor sensors; heading sensors; ground-based beacons; active ranging; motion and speed sensors; vision-based sensors; representing uncertainty; statistical representation; error propagation; feature extraction using range and visual data.	07
04	Mobile Robot Localization	Introduction to localization; challenges of localization — noise and aliasing; sensor noise; sensor aliasing; effector noise; odometric error models; localization-based navigation; belief representation; map representation; probabilistic map-based localization; Markov localization; Kalman filter localization; landmark-based navigation; positioning beacon systems; route-based localization.	08
05	Autonomous Mapping and Navigation	Autonomous map building; stochastic map technique; other mapping techniques; introduction to planning and	08

Module No.	Module Name	Module Contents	No. of Hours
		navigation; competences for navigation — planning and reacting; path planning; obstacle avoidance techniques.	
06	Navigation Architectures	Navigation architectures; modularity for code reuse and sharing; control localization; techniques for decomposition; case studies of tiered robot architectures; introduction to modern navigation systems and autonomous mobile robots.	08
Total			45

Suggested List of Value-Added Home Assignments

1. Design and simulate a wheeled mobile robot capable of autonomous navigation and obstacle avoidance in an indoor environment using ultrasonic or LiDAR sensors.
2. Develop a vision-based mobile robot system for object detection and sorting using a camera and a basic machine learning or image processing technique.
3. Implement a mobile robot simulation that performs path planning and navigation for automated material handling in a warehouse environment.
4. Design a voice-controlled mobile robot using speech recognition tools to execute commands such as movement, navigation, or environmental monitoring.
5. Build a prototype or simulation of a surveillance mobile robot capable of detecting motion or intrusions and generating alerts through a monitoring interface.
6. Simulate a multi-robot system for cooperative exploration and mapping of an unknown environment using onboard sensors and communication between robots.

Problem-Based Experiments (PBL List)

1. Study different types of mobile robots and compare legged and wheeled locomotion using suitable case studies or simulations.
2. Analyze the stability and maneuverability of legged mobile robots for different leg configurations.
3. Simulate wheeled mobile robots and study the effect of wheel arrangements on robot motion.
4. Develop a kinematic model for a differential drive robot and simulate its movement for different velocity inputs.
5. Analyze wheel kinematic constraints and robot kinematic constraints for mobile robotic systems.
6. Study the maneuverability of holonomic and non-holonomic robots using simulation tools.
7. Implement open-loop and feedback motion control for trajectory tracking of a mobile robot.
8. Interface and simulate wheel encoders, ultrasonic sensors, LiDAR, and vision sensors for mobile robots.
9. Analyze the performance characteristics of different sensors used in mobile robots.
10. Represent uncertainty in sensor measurements and study error propagation using simulated sensor data.
11. Perform feature extraction using range data or vision-based sensor inputs for object identification.
12. Implement dead reckoning localization using odometry data and analyze localization errors.
13. Apply Kalman filter localization for improving robot pose estimation using sensor fusion.
14. Implement particle filter or Markov localization techniques in a known environment.

15. Develop and compare different map representation methods for mobile robot navigation.
16. Simulate landmark-based and beacon-based localization methods for autonomous robots.
17. Implement autonomous map building using basic SLAM or stochastic mapping techniques.
18. Develop path planning algorithms for mobile robot navigation in obstacle-filled environments.
19. Implement obstacle avoidance techniques for autonomous mobile robots using sensor inputs.
20. Study modular navigation architectures and simulate autonomous navigation of a mobile robot in ROS or a virtual environment.

Recommended Online Courses:

1. Computer Vision Specialization (by University of Buffalo)
<https://www.coursera.org/specializations/computer-vision>
2. NPTEL: Wheeled Mobile Robots, IITM IIT Palakkad. nptel.ac.in/courses/112106298
3. Computer Vision, <https://www.udacity.com/course/computer-vision-nanodegree--nd891>
4. OpenCVBootcamp, https://opencv.org/university/free-opencv-course/?utm_source=google&utm_medium=cpc&utm_campaign=WW_tut_OBC&utm_term=best%20opencv%20tutorial&gad_source=1&gad_campaignid=21004628838&gbraid=0AAAAACbv-xhUM70mKirK31LiktTRipo8G&gclid=Cj0KCQjw9O_BBhCUARIsAHQMjS7VA3JEdz8KONvGanFNC7KAqSt2HModiDtp5hB_PJKX_oTK80pNxQaAlcVEALw_wcB

Reference Books / Articles

1. Siegwart, Roland, Illah R. Nourbakhsh, and Davide Scaramuzza, Introduction to Autonomous Mobile Robots, MIT Press, 2nd Edition, 2011.
2. Choset, Howie, Kevin M. Lynch, Seth Hutchinson et al., Principles of Robot Motion: Theory, Algorithms, and Implementations, MIT Press, 1st Edition, 2005.
3. Russell, Stuart J., and Peter Norvig, Artificial Intelligence: A Modern Approach, Pearson Education, 3rd Edition, 2010.
4. Craig, John J., Introduction to Robotics: Mechanics and Control, Pearson Education, 3rd Edition, 2009.
5. Wooldridge, Michael, An Introduction to MultiAgent Systems, Wiley, 2nd Edition, 2009.
6. Grover, Vikram, Mastering UiPath Studio: A Beginner's Guide to Robotic Process Automation, BPB Publications, 1st Edition, 2021.

Course Name: Professional Competency Development 2

Course Code: OEC15

Vertical/ Sub-Vertical: Open Elective Courses

K-S-A Mapping: Skill

Pre-requisite required: OEC14 (Professional Competency Development 1)

Pre-requisite for: OEC16 (Professional Competency Development 3)

Course Level:

Recommended Semester: 5

Preamble:

Professional Competency Development 2 strengthens your problem-solving foundations through hands-on data structures, algorithms, and Java's Collections Framework. Emphasizing both competitive programming patterns and technical interview depth, the course builds fluency in stacks, queues, linked lists, trees, and graphs. You will analyze complexities, choose optimal structures for real problems, and implement efficient solutions. By the end, you'll be able to reason about performance, write clean code, and tackle end-to-end coding challenges with confidence.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2		1

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	50	-	-	-

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Course Objectives:

- Build strong proficiency with core and advanced data structures in Java (Collections Framework), selecting the right structure for problem-specific constraints.
- Develop the ability to analyze and optimize algorithms using sliding window, prefix sums, and recurrence methods.
- Master implementation patterns for stacks, queues, linked lists, trees, and graphs, including iterative traversals, balanced BSTs, heaps, and tries.
- Apply competitive programming techniques and problem-solving approach to design clean, efficient, and correct solutions.

- Cultivate industry-ready habits: clarity of thought, complexity-aware coding, test-driven validation, and effective use of standard libraries.

Course Outcomes:

Learner will be able to:

Course Outcomes	Course Outcome Statement	Bloom's Level
CO1	Describe and differentiate core Java Collections like lists, sets, maps, queues, and heaps with respect to their key operations, typical use cases, and trade-offs.	Understand
CO2	Apply sliding window, prefix sums, hashing, and two-pointers to solve coding problems efficiently.	Apply
CO3	Implement stack- and queue-based solutions and apply them to expression evaluation, recursion simulation, and other linear-time problem patterns.	Apply
CO4	Implement linked-list solutions like reverse, rotate, merge sorted lists, and detect cycles and intersections using correct pointer techniques and linear-time approaches.	Apply
CO5	Develop and analyze tree-based solutions by writing iterative traversals and level order, perform BST insert/delete, and leverage balanced trees, tries, and Huffman coding when they best fit the problem's constraints and efficiency goals.	Analyze
CO6	Model problems as graphs and solve using BFS/DFS, shortest paths, topological ordering, and MST algorithms, with complexity analysis.	Analyze

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours	CO's Mapped
1	Java Collection Framework	Arrays, String vs StringBuilder, ArrayList, Linked List, Stack, Queue Interface, Double Ended Queue, Priority Queue and Heap Hash Set, Linked Hash Set, Tree Set Hash Map, Linked Hash Map, Tree Map Understand the functions provided and problem specific usage.	05	CO1
2	Advance Concepts and Algorithm Analysis	Topics for Competitive Coding: Strings and Substrings, Arrays and Hashing, Sliding Window Concept, Prefix Sum Topics for Technical Interview:	05	CO2

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		Java Collection Framework, Asymptotic Analysis, Growth Functions, Recurrence Relation, Master Method		
3	Advance Concepts on Stack, Queues	Topics for Competitive Coding: Monotonic Stack and Queues, Min-Stack, Max-Stack, Implement Queue using Two Stacks, Implement Stack Using Two Queues, Double Ended Queue, Priority Queue and Heap Topics for Technical Interview: Applications of Stack, Expression Conversion and Evaluation using Stack, Simulation of Recursion using Stack, Backtracking with Stack (Undo Operation)	05	CO3
4	Advance Concepts on Linked List	Topics for Competitive Coding: Detecting Cycle in Linked List, Concept of Slow-Fast Pointers, Intersection of Two Linked Lists Reversing Linked List and Sub List, Rotating Linked List, Merging Two Sorted Lists, Palindrome Linked List, Add Two Numbers Represented in Linked List, Topics for Technical Interview: Array Representation of Linked List, Array vs Linked List, Representing Polynomial Using Linked List, Array of Linked List	05	CO4
5	Advanced Concepts on Trees	Topics for Competitive Coding: Iterative Inorder/Postorder with Stack, Binary Tree Level Order Traversals, Diameter of Binary Tree, Deletion of Node from BST Topics for Technical Interview: Height Balanced Checks, AVL Trees – rotations, insertion, Tries, Red and Black Tree, Expression Tree, Huffman Encoding	05	CO5
6	Advance Concepts on Graphs	Topics for Competitive Coding:	05	CO6

		Problems on Graph Traversals, Problems using Visited Array, All Paths from Source to Target, Shortest Path Problems, Directed and Undirected Graph Problems Topics for Technical Interview: Graph Representation, Topological Sorting, Minimum Cost Spanning Tree Algorithms, Directed Acyclic Graph,		
Total			30	

Tools/ Technologies/ Programming Languages learnt:

- Programming Languages: Java.
- Integrated Development Environments (IDEs): Visual Studio Code, Eclipse.
- Code Practice Platforms: LeetCode, HackerRank, CodeSignal.
- Version Control Systems: Git and GitHub.
- Online Learning Platforms with Interactive Coding Environments: Jupyter Notebook, Repl.it.

Textbooks:

1. S. Dasgupta, C. H. Papadimitriou, and U. V. Vazirani, Algorithms. New York, NY, USA: McGraw-Hill, 2008.
2. M. T. Goodrich, R. Tamassia, and M. H. Goldwasser, Data Structures and Algorithms in Java, 6th ed. Hoboken, NJ, USA: Wiley, 2014.
3. Herbert Schildt, "JAVA: The Complete Reference", Oracle Press.
4. Sachin Malhotra and Saurabh Chaudhary, "Programming in JAVA", Oxford University Press

Reference Books:

1. M. A. Weiss, Data Structures and Algorithm Analysis in Java, 3rd ed. Upper Saddle River, NJ, USA: Addison-Wesley, 2012.
2. R. Sedgewick and K. Wayne, Algorithms, 4th ed. Upper Saddle River, NJ, USA: Addison-Wesley, 2011.
3. Stevan Jolzner, "JAVA Programming- Black Book", Dreamtech Press.

Online References:

1. Java Collection Framework
Link: <https://docs.oracle.com/javase/tutorial/collections/index.html>
2. Princeton Algorithms, Part I — Linked lists lecture/notes.
Link: <https://algs4.cs.princeton.edu/13stacks/>
3. Codeforces EDU (theory + practice problemsets).
Link: <https://codeforces.com/edu>

Detailed Syllabus of Third Year Semester - VI

Course Name: Operating System

Course Code: PCEC10T

NEP Vertical Basket: PC_PCC

Preamble:

The goal of the course is to introduce the students to modern operating systems design. This course covers the design and implementation of operating systems with a focus on modern, concurrent kernels.

Pre-requisites:

Data Structure

Course Objectives:

- To enable learner to understand how operating system manages allocation and deallocation of different resources needed by user/ application.
- To enable learner to understand how operating system controls access to various resources and provides security.
- To enable learner to evaluate performance of different approaches used by operating systems, for effective resource utilization.

Course Outcomes:

Learner will be able to:

CO1: Understand the benefits of software modularity and how it applies to OS design.
CO2: Compare various OS scheduling policies based on performance parameters.

CO3: Analyze methods to achieve synchronization and handle deadlocks.

CO4: Evaluate performance of Memory allocation and replacement policies.

CO5: Compare various files and I/O management techniques.

CO6: Understand how principles of general OS are applied in Linux OS.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	075

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table.

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Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose a revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to Operating System	Operating System definitions, Functions of Operating System, Operating System Structures, User mode and kernel mode of a process, Types of Operating System, System Calls, Booting	4
2	Process Management and Synchronization	Process Management: Definition of Process, Process Control Block, Process Scheduling: Types and scheduling algorithms (FCFS, SJF, SRTN, Priority, RR), Threads: Definition and Concept of Multithreading. Process Synchronization: Principles of Concurrency, Inter-process communication, Critical-Section Problem, Peterson's Solution, Synchronization Hardware, Semaphores, Producer and Consumer problem,	6
3	Deadlock	Principles of Deadlock: Conditions and Resource, Allocation Graphs, Deadlock Prevention, Deadlock Avoidance: Banker's Algorithm, Deadlock Detection and Recovery, Dining Philosophers Problem.	5
4	Memory Management	Memory Management Requirements, Memory Partitioning: Fixed, Partitioning, Dynamic Partitioning, Memory Allocation Strategies: Best-Fit, First Fit, Worst Fit, Paging and Segmentation, TLB, Page table design Virtual Memory: Demand Paging, Page Replacement Strategies: FIFO, Optimal, LRU	6
5	File Systems and I/O Management	Files and File Systems, Directory Systems, File allocation methods: Contiguous allocation, Linked allocation, Indexed allocation, Kernel I/O subsystem, Communication and Data Transfer with I/O Devices, Disk Organization, I/O Management and Disk Scheduling: FCFS, SSTF, SCAN, CSCAN, LOOK, C-LOOK, RAID Structure	5
6	The Linux System	Design Principles, Kernel Modules, Process Management, Scheduling, Memory Management, File Systems	3
Total			30

Textbooks:

1. William Stallings, Operating System: Internals and Design Principles, Prentice Hall, 8th Edition, 2014, ISBN-10: 0133805913 • ISBN-13: 9780133805918
2. Abraham Silberschatz, Peter Baer Galvin and Greg Gagne, Operating System Concepts, John Wiley & Sons, Inc., 9th Edition, 2016, ISBN 978-81-265-5427-0
3. Andrew Tannenbaum, Operating System Design and Implementation, Pearson, 3rd Edition.

Reference Books:

1. Sumitabha Das, "UNIX: Concepts and Applications", McGraw Hill, 4thEdition
2. Achyut Godbole and Atul Kahate, Operating Systems, McGraw Hill Education, 3rdEdition

Course Name: Operating System Lab

Course Code: PCEC10P

NEP Vertical Basket: PC_PCC

Preamble:

The course introduces learners to Linux shell commands and simulate various algorithms used by generalOS for managing resources. This courses project will explore the key operating system facilities in the relative isolation of an OS development framework with the goal of maximizing experiential learning.

Pre-requisites:

Data Structure Lab

Course Objectives:

- To enable learner to visualize the working of operating system by simulating techniques used by itto manage resources.
- To enable learner to apply techniques of process synchronization in multithreaded programs and hence develop concurrent applications.

Course Outcomes:

Learner will be able to:

CO1: Understand various shell commands of Linux OS.

CO2: Compare performance of different process scheduling policies.

CO3: Perform process/ thread synchronization for consistency and concurrency.

CO4: Simulate OS techniques for memory and virtual memory management.

CO5: Develop project to explore key OS facilities.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Practical	25	-	25	050

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Linux commands
2.	Non-Preemptive process Scheduling
3.	Preemptive process Scheduling
4.	Process synchronization using mutex locks.
5.	Deadlock Handling
6.	Dynamic memory allocation techniques
7.	Address translation in virtual memory
8.	Page replacement policies
9.	Disk scheduling techniques

Textbooks:

2. William Stallings, Operating System: Internals and Design Principles, Prentice Hall, 8thEdition, 2014,ISBN-10: 0133805913 • ISBN-13: 9780133805918
3. Abraham Silberschatz, Peter Baer Galvin and Greg Gagne, Operating System Concepts, John Wiley & Sons, Inc., 9thEdition, 2016, ISBN 978-81-265-5427-0
4. Andrew Tannenbaum, Operating System Design and Implementation, Pearson, 3rdEdition.

Reference Books:

2. Sumitabha Das, "UNIX: Concepts and Applications", McGraw Hill, 4thEdition
2. Achyut Godbole and Atul Kahate, Operating Systems, McGraw Hill Education, 3rdEdition

Course Name: Theory of Computer Science

Course Code: PCEC12T

NEP Vertical Basket: PC_PCC

Preamble:

This course introduces students to formal language and automata theory. It covers different types of grammars and automata of different powers that are required to recognize languages defined by the grammars.

Pre-requisites:

BS05 (Engineering Mathematics 3)

Course Objectives:

- Acquire conceptual understanding of fundamentals of grammars and languages.
- Build concepts of theoretical design of deterministic and non-deterministic finite automata and push down automata.
- Develop understanding of different types of Turing machines and applications.

Course Outcomes:

Learner will be able to:

CO1: Express rules in mathematical form (grammar).

CO2: Classify the problem into appropriate type of grammar.

CO3: Apply equivalence theory to recognize power of different automata.

CO4: Design Automata to meet the required specifications.

CO5: Create a tool that designs automata for a given grammar.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Tutorial	Theory	Tutorial
2	1	2	1

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory + Tutorial	40	20	40	100

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Fundamentals of Automata Theory	Basic Mathematical Fundamentals: Set Theory, Logic, Relations and Functions.	4
2	Introduction to Language & Finite Automata	Concepts: Symbol, Alphabet, Language and Grammar. Types of Grammar and Automata. Deterministic: 5-tuple representation of DFA. Designing DFA for Regular Language. Minimization of DFA. Non-Deterministic: 5-tuple representation of NFA with epsilon moves and NFA without epsilon moves. Equivalence of language recognized by NFA and DFA.	6
3	Regular Language and Grammar	Regular Expression and Regular Grammar. Equivalence of FA and Regular Expression. Properties of Regular Sets/ Languages. Classifying language as Regular and Non-regular.	4
4	Context Free and Sensitive Languages	Concepts: CFG, CFL, Derivations and Ambiguity. CFL as a superset of Regular. Normal Forms (CNF and GNF). Properties of CFL.	6
5	Push-Down Automata	7-tuple Deterministic PDA. Deterministic and NonDeterministic PDA. Equivalence of NPDA and CFL.	4
6	Turing Machine	Basic 7-tuple Turing Machine (TM). TM as acceptor & generator. Recursive and RE Languages. Decidability & Undecidability.	6
Total			30

Suggestion for list of Tutorials:

1. At-least one tutorial on each module. Recommended to add additional tutorials for module 3, 5 and 7.
2. Questions should be short and conceptual only. Each tutorial should be designed worth 2 Marks. Required to be solvable in 5 to 10 mins.
3. Tutorial to have major questions mapping to level 1 of Blooms Taxonomy (Understanding) and few questions mapping to level 2 of Blooms Taxonomy (Applying).

Text Books:

1. John E. Hopcroft, Rajeev Motwani and Jeffrey D. Ullman. Introduction to Automata Theory, Languages and Computation. Pearson Education. 2008.
2. Michael Sipser. Introduction to the Theory of Computation. Thomson Course Technology. 2012.
3. Peter Linz. An Introduction to Formal Languages and Automata. Jones and Bartlett Student Edition. 2016.

Course Name: Analog & Digital Communications

Course Code: PCEC14T

NEP Vertical Basket: PC_PCC

Preamble:

In this course students will learn the fundamental principles and techniques behind the transmission of analog & digital signals. Through a blend of theoretical concepts and practical applications, students will explore the evolution from traditional analog to modern digital communication systems. Topics include modulation, coding, multiplexing, noise analysis, and coding. Emphasis will be placed on understanding signal propagation, channel capacity, and the impact of noise on communication quality. By the end, students will possess a solid foundation in both analog and digital communication principles, preparing them for diverse real-world challenges in the field.

Pre-requisites:

- BS06 (Engineering Mathematics-III)
- BS08 (Engineering Mathematics-IV)
- EC06 (Signals and Systems-IV)

Course Objectives:

- To understand the fundamental concepts and methods employed in analog and digital communications.
- To learn different modulation techniques used in analog and digital, and how they're applied in communication systems.
- To explore baseband and bandpass communication methods, as well as various coding techniques used in data transmission.
- To analyze the effect of noise in communication systems and learn about different multiplexing techniques utilized in transmitting multiple signals over a single channel.

Course Outcomes:

Learner will be able to:

CO1: Understand the fundamental principles and components of communication systems.

CO2: Apply knowledge of basic analog communication systems.

CO3: Evaluate the effects of noise on communication systems.

CO4: Interpret the principles governing digital communication systems.

CO5: Create and execute error control coding schemes to enhance communication reliability.

CO6: Investigate the practical applications of multi-user radio communication through case studies and applications.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	075

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction to communication systems	- Basic elements of a communication system (source, transmitter, channel, receiver, destination) - Signal representation: time domain and frequency domain (Fourier Series & Fourier Transform) - Introduction to communication models	6
2	Analog communication systems	- Amplitude Modulation (AM): Double-sideband suppressed carrier (DSB-SC) modulation, Single-sideband (SSB) modulation and Vestigial sideband (VSB) modulation, AM receivers: envelope detector. - Angle Modulation (FM): Wideband FM (WBFM) and Narrowband FM (NBFM), FM receivers: discriminator.	6
3	Noise Analysis in communication systems	- Introduction to noise sources (thermal noise, shot noise) - Signal-to-Noise Ratio (SNR) and its importance. - Noise analysis in communication systems - Inter symbol inference, Inter channel interference	3

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4	Digital communication systems	• Introduction to digital signals and baseband transmission • Sampling theorem and Nyquist rate • Quantization and pulse code modulation (PCM) • Line coding techniques: Unipolar, Bipolar, Polar, RZ, NRZ, Manchester, Differential Manchester • Digital modulation techniques: Binary Phase Shift Keying (BPSK), Binary Amplitude Shift Keying (BASK), Binary Frequency Shift Keying (BFSK) Quadrature Phase Shift Keying (QPSK), Quadrature Amplitude Phase Shift Keying (QAPSK)	8
5	Error control coding	• Error control coding: Channel Capacity, Linear Block Codes, Cyclic Codes – ARQ Techniques • Simulation of error control coding schemes.	4
6	Multi-user radio communication	• Global System for Mobile Communications (GSM) – Code Division Multiple Access (CDMA) – Cellular • Concept and Frequency Reuse – Channel Assignment and Handover Techniques – Overview of Multiple Access Schemes – Satellite Communication, Optical Fiber Communication, Mobile communication	3
Total			30

Textbooks:

1. B.P. Lathi "Modern Digital and analog Communication system" Third Edition, OXFORD.
2. Taub and Schilling, "Principles of communication systems", Tata McGraw Hill.
3. Simon Haykin, "Communication Systems", 4th Edition, John Wiley & Sons.
4. Rappaport T.S, "Wireless Communications: Principles and Practice", 2nd Edition.

Reference Books:

1. Wayne Tomasi, "Electronics communication systems" Pearson Education, Third Edition, 2001.
2. Roy Blake, "Electronics communication system," Thomson learning, Second Edition.
3. Blake, "Electronic Communication Systems", Thomson Delmar Publications, 2002.
4. B. Sklar, "Digital Communication Fundamentals and Applications" 2nd edition
5. Robert J. Schoenbeck, "Electronics communications modulation and transmission"
6. Lean W couch, "Digital and Analog communication system", Pearson Education, Sixth Edition
7. Roddy Coolen, "Electronic Communications" PHI

Course Name: Analog & Digital Communications Lab

Course Code: PCEC14P

NEP Vertical Basket: PC_PCC

Preamble:

In this course students will learn the fundamental principles and techniques behind the transmission of analog & digital signals. Through a blend of theoretical concepts and practical applications, students will explore the evolution from traditional analog to modern digital communication systems. Topics include modulation, coding, multiplexing, noise analysis, and coding. Emphasis will be placed on understanding signal propagation, channel capacity, and the impact of noise on communication quality. By the end, students will possess a solid foundation in both analog and digital communication principles, preparing them for diverse real-world challenges in the field.

Pre-requisites:

- BS06 (Engineering Mathematics-III)
- BS08 (Engineering Mathematics-IV)
- EC06 (Signals and Systems-IV)

Course Objectives:

- To simulate different modulation techniques used in analog and digital, and how they're applied in communication systems.
- To explore various coding techniques used in data transmission.
- To analyze the effect of noise in communication systems and learn about different multiplexing techniques utilized in transmitting multiple signals over a single channel.

Course Outcomes:

Learner will be able to:

CO1: Apply knowledge of basic analog communication systems.

CO2: Simulate the principles governing digital communication systems.

CO3: Create and execute error control coding schemes to enhance communication reliability.

CO4: Investigate the practical applications of multi-user radio communication through case studies and applications.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	25	--	25	050

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Suggested List of Practical's:

Sr No.	Suggested Topic(s)
11.	Amplitude modulation - generation and detection
12.	Frequency modulation generation and detection
13.	Simulation of AM/ FM receiver
14.	Signal sampling and reconstruction
15.	PCM coding and decoding
16.	Line Coding
17.	Linear Block Codes
18.	BPSK Modulation & Demodulation
19.	BFSK Modulation & Demodulation
20.	BASK Modulation & Demodulation
21.	QPSK Modulation & Demodulation

Useful Tools and Laboratory: -

1. NPTEL MOOC Courses
2. Swayam Portal AICTE
3. National Digital Library, IIT KGP.
4. Virtual Lab by IIT Bombay.
5. MATLAB
6. SCILAB
7. LABVIEW
8. Various Analog and Digital Communication Trainers.

Text Books:

1. B.P. Lathi "Modern Digital and analog Communication system" Third Edition, OXFORD.
2. Taub and Schilling, "Principles of communication systems", Tata McGraw Hill.
3. Simon Haykin, "Communication Systems", 4th Edition, John Wiley & Sons.
4. Rappaport T.S, "Wireless Communications: Principles and Practice", 2nd Edition.

Reference Books:

1. Wayne Tomasi, "Electronics communication systems" Pearson Education, Third Edition, 2001.
2. Roy Blake, "Electronics communication system," , Thomson learning, Second Edition.
3. Blake, "Electronic Communication Systems", Thomson Delmar Publications, 2002.
4. B. Sklar, "Digital Communication Fundamentals and Applications" 2nd edition
5. Robert J. Schoenbeck, "Electronics communications modulation and transmission"
6. Lean W couch, "Digital and Analog communication system", Pearson Education, Sixth Edition
7. Roddy Coolen, "Electronic Communications" PHI

Detailed Syllabus of AIML Track – Sem V & VI

Course Name: Artificial Intelligence

Course Code: PEEC01T

NEP Vertical Basket: PC_PEC

Preamble:

Intelligent machines have replaced human capabilities in many areas. Artificial intelligence is the intelligence exhibited by machines or software. It emphasizes creating intelligent machines that work and react like humans.

Pre-requisites:

NIL

Course Objectives:

1. Understand Artificial Intelligence
2. Know and use various problem-solving methods
3. Acquire and use knowledge representation methods in AI
4. Understand and design Artificial intelligence Agents
5. Know and identify AI applications
6. Design and apply Artificial Intelligence in community

Course Outcomes:

Learner will be able to:

CO1: To understand the basics of Artificial Intelligence

CO2: To know and use various problem-solving methods

CO3: To acquire and use knowledge representation methods in AI

CO4: To understand and design Artificial intelligence Agent

CO5: To know and identify AI applications

CO6: To design and apply Artificial Intelligence in community

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	75

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall decide her/his assessment methodology based on the course's nature. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

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Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to Artificial Intelligence	- Artificial Intelligence Introduction, Intelligent systems - Categorization of Intelligent Systems - Characteristics of AI - Current Trends in AI	4
2	Intelligent Agents	- Agents and Environment, Structure of Agents, Types of agents, Learning agent, - Agent communication - Negotiation and Bargaining - Argumentation among Agents - Trust and Reputation in Multi-agent systems	5
3	Problem Solving Methods	- Uninformed search Breadth First Search, Depth First Search, Depth First iterative deepening, - Informed Search Greedy best first, A*, Heuristic search - Adversarial Search Game playing, alpha beta pruning, Min-Max search - Local search algorithms and optimization Hill climbing search, Genetic algorithms,	6
4	Knowledge Representation	- Knowledge Representation, brief overview of propositional logic, FOL syntax and semantic, forward chaining and backward chaining - Unification, resolution, - Uncertain knowledge and Engineering: knowledge in uncertain domain, semantics of belief network, simple inference in belief network	6
5	Planning and Learning	- Planning: Planning problem, Partial order planning, Hierarchical planning, Conditional planning - Learning: Forms of Learning, Theory of learning, PAC learning, Introduction to statistical learning	5
6	Artificial Intelligence Applications with Real Time USECASE	Students are supposed to study any AI Application and provide insights about the concepts used in respective application.	4
Total			30

Textbooks:

1. Artificial Intelligence: A Modern Approach (AIMA) is a university textbook on artificial intelligence, written by Stuart J. Russell and Peter Norvig.
2. S. Russel and P. Norvig, "Artificial Intelligence – A Modern Approach", Second Edition, Pearson Education

Reference Books:

1. David Poole, Alan Mackworth, Randy Goebel, "Computational Intelligence: a logical approach", Oxford University Press.
2. G. Luger, "Artificial Intelligence: Structures and Strategies for complex problem solving", Fourth Edition, Pearson Education.
3. J. Nilsson, "Artificial Intelligence: A new Synthesis", Elsevier Publishers.

Course Name: Artificial Intelligence Lab

Course Code: PEEC01P

NEP Vertical Basket: PC_PEC

Preamble:

Intelligent machines have replaced human capabilities in many areas. Artificial intelligence is the intelligence exhibited by machines or software. It emphasizes creating intelligent machines that work and react like humans. AI labs will help to understand these concepts with practical experiments.

Pre-requisites:

NIL

Course Objectives:

- Understand Artificial Intelligence
- Know and use various problem-solving methods
- Acquire and use knowledge representation methods in AI
- Understand and design Artificial intelligence Agents
- Know and identify AI applications
- Design and apply Artificial Intelligence in community

Course Outcomes:

Learner will be able to:

CO1: To understand and conceptualize basic ideas and techniques in artificial Intelligence

CO2: To know and use various problem-solving methods

CO3: To acquire and choose appropriate knowledge representation methods in AI

CO4: To understand and design Artificial intelligence Agents

CO5: To know and identify AI applications

CO6: To design and develop Artificial Intelligence Applications in real world scenarios

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Practical	25	-	25	50

Suggested List of Practicals:

Sr No.	Title of Practicals
1	One case study on AI applications published in IEEE/ACM/ Springer Journals
2	Program on uninformed search methods (BFS)
3	Program on uninformed search methods (DFS)
4	Program on informed search methods (A *)
5	Program on game playing assignments (Minmax)

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6	Program on First order logic
7	Project (Develop any small AI Application)

Course Name: Soft Computing

Course Code: PEEEC05T

NEP Vertical Basket: PC_PEC

Preamble:

Soft computing is an emerging approach to computing based on some biological inspired methodologies such as genetics, evolution, ant's behaviors, particles swarming, human nervous systems, etc. Now, soft computing is the only solution when we don't have any mathematical modeling of problem solving (i.e., algorithm), need a solution to a complex problem in real time, easy to adapt with changed scenario and can be implemented with parallel computing. It has enormous applications in many application areas such as medical diagnosis, computer vision, handwritten character reconitions, pattern recognition, machine intelligence, weather forecasting, network optimization, VLSI design, etc.

Pre-requisites:

- Engineering Mathematics (All Semesters)

Course Objectives:

After completing this course, you will be able to learn:

- Fuzzy logic and its applications.
- Artificial neural networks and its applications.
- Solving single-objective optimization problems using GAs.
- Solving multi-objective optimization problems using Evolutionary algorithms (MOEAs).
- Applications of Soft computing to solve problems in varieties of application domains.

Course Outcomes:

Learner will be able to learn:

CO1: Explain the fundamentals of soft computing, its constituents, and its adaptability.

CO2: Apply fuzzy set theory and design membership functions for imprecise data.

CO3: Develop fuzzy inference systems using Mamdani and Sugano models for decision-making.

CO4: Solve optimization problems using genetic algorithms and their operators.

CO5: Implement neural network algorithms for supervised and unsupervised learning tasks.

CO6: Design hybrid systems like ANFIS by integrating neural networks and fuzzy logic.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	75

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction to Soft Computing	Soft computing Constituents, Characteristics of Neuro Computing and Soft Computing, Difference between Hard Computing and Soft Computing, Concepts of Learning and Adaptation.	4
2	Fuzzy Set Theory	Fuzzy Sets, Fuzzy relations, Fuzzification and Defuzzification. Features of the membership Functions, Fuzzy Max-Min and Max-Product Composition	4
3	Fuzzy Rules, Reasoning and Inference System	Fuzzy Rules: Fuzzy If-Then Rules, Fuzzy Reasoning Fuzzy Inference System (FIS): Mamdani FIS, Sugano FIS, Comparison between, Mamdani and Sugano FIS	4
4	Genetic Algorithm	An Introduction to genetic Algorithms: Genetic Algorithms Mathematical Foundations, Schemata Revisited Implementation of a Genetic Algorithm: Data Structures, Reproduction, Crossover, and Mutation, Algorithm for Handwriting Recognition Using GA Generation of Graph, Fitness Function of GA, Generation of Graph Results of Handwriting Recognition, Effect of Genetic Algorithms, Distance Optimization, Style Optimization, Solving single-objective optimization problems using GA, Multi-objective Optimization Problem Solving	6
5	Neural Networks	Basics of Neural Networks: Introduction to Neural Networks, Biological Neural Networks, McCulloch Pitt model Supervised Learning algorithms: Perceptron (Single Layer, Multi-layer), Linear separability, Delta learning rule, Back Propagation algorithm, Un-Supervised Learning algorithms: Hebbian Learning, Winner take all, Self Organizing Maps, Learning Vector Quantization.	8
6	Hybrid system	Introduction to Hybrid Systems, Adaptive Neuro Fuzzy Inference System (ANFIS)	4
Total			30

Textbooks:

1. Principles of Soft Computing, S.N. Sivanandam, S.N. Deepa, Willey, 2nd
2. An Introduction to Genetic Algorithms, Melanie Mitchell, MIT Press
3. Neural Networks, Fuzzy Logis and Genetic Algorithms : Synthesis, and Applications, S. Rajasekaran, and G. A. Vijayalakshmi Pai, Prentice Hall of India
4. Fuzzy Logic with Engineering Applications (3rd Edn.), Timothy J. Ross, Willey

Reference Books:

1. Practical Genetic Algorithms, Randy L. Haupt and sue Ellen Haupt, John Willey & Sons, 2002.
2. Genetic Algorithms In Search, Optimization And Machine Learning, David E. Goldberg, Pearson Education
3. Fuzzy Logic: A Pratical approach, F. Martin, , Mc neill, and Ellen Thro, AP Professional

Course Name: Soft Computing Lab

Course Code: PEEEC05P

NEP Vertical Basket: PC_PEC

Preamble:

Soft computing provides a reliable solution when we don't have any mathematical modeling of problem solving (i.e., algorithm), need a solution to a complex problem in real time, easy to adapt with changed scenario and can be implemented with parallel computing. It has enormous applications in many application areas such as medical diagnosis, computer vision, handwritten character reconstructions, pattern recognition, machine intelligence, weather forecasting, network optimization, VLSI design, etc

Pre-requisites:

- Engineering Mathematics (All Semesters)

Course Objectives:

After completing this course, you will be able to learn:

- Fuzzy logic and its applications.
- Artificial neural networks and their applications.
- Solving single-objective optimization problems using GAs.
- Solving multi-objective optimization problems using Evolutionary algorithms (MOEAs).
- Applications of Soft computing to solve problems in varieties of application domains.

Course Outcomes:

Learner will be able to learn:

CO1: Explain the fundamentals of soft computing, its constituents, and its adaptability.

CO2: Apply fuzzy set theory and design membership functions for imprecise data.

CO3: Develop fuzzy inference systems using Mamdani and Sugeno models for decision-making.

CO4: Solve optimization problems using genetic algorithms and their operators.

CO5: Implement neural network algorithms for supervised and unsupervised learning tasks.

CO6: Design hybrid systems like ANFIS by integrating neural networks and fuzzy logic.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	25	--	25	50

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Suggested List of Practical's:

Sr No.	Suggested List of Experiments
1.	Study of Fuzzy set and Theory
2.	Implementing basic fuzzy Operations
3.	Implementation of fuzzy set close to N
4.	Study of the Fuzzy toolbox.
5.	Implementing Train Controller problem
6.	Implementing Washing machine problem
7.	Implementing Water purification problem
10.	Implementing Tipper problem
11.	Implementing the Perceptron learning rule.
12.	Implementing the Curve Fitting using Genetics algorithm.
13.	Development of an Adaptive Neuro-Fuzzy Inference System (ANFIS)
14.	Backpropagation Algorithm for Multilayer Perceptron

Text Books:

1. Principles of Soft Computing, S.N. Sivanandam, S.N. Deepa, Willey, 2nd
2. An Introduction to Genetic Algorithms, Melanie Mitchell, MIT Press
3. Neural Networks, Fuzzy Logis and Genetic Algorithms : Synthesis, and Applications, S. Rajasekaran, and G. A. Vijayalakshmi Pai, Prentice Hall of India
4. Fuzzy Logic with Engineering Applications (3rd Edn.), Timothy J. Ross, Willey

Reference Books:

1. Practical Genetic Algorithms, Randy L. Haupt and sue Ellen Haupt, John Willey & Sons, 2002.
2. Genetic Algorithms In Search, Optimization And Machine Learning, David E. Goldberg, Pearson Education.
3. Fuzzy Logic: A Practical approach, F. Martin, , Mc neill, and Ellen Thro, AP Professional.

Course Name: Machine Learning

Course Code: PEEC09T

NEP Vertical Basket: PC_PEC

Preamble:

This course is designed to provide students with a comprehensive understanding of fundamental concepts, algorithms, and techniques in machine learning. Through a combination of theoretical lectures, hands-on lab sessions, and real-world projects, students will gain the necessary knowledge and skills to apply machine learning effectively in practical scenarios.

Pre-requisites:

- EC09 (Python Programming)

Course Objectives:

- To understand Machine Learning Concepts.
- To apply various data processing techniques.
- To understand and apply supervised and unsupervised algorithm concepts.
- To apply knowledge of machine learning to solve real-world problems.

Course Outcomes:

Students will be able to:

CO1: Understand the fundamental concepts and scope of Machine Learning.

CO2: Apply various techniques of Data Preprocessing to clean, transform, and prepare raw data.

CO3: Analyse and interpret the concepts and model representations of Linear Regression and Logistic Regression.

CO4: Compare decision trees, random forests, and ensemble methods for supervised learning.

CO5: Utilize clustering algorithms along with dimensionality reduction techniques to identify patterns and reduce the dimensionality of data.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head	ISA	MSE	ESE	Total
Theory	15	20	40	75

Detailed Syllabus:

Module no	Module name	Content	No of Hours
1	Introduction to Machine Learning	Introduction to ML, Definition and scope of Machine Learning, Types of Machine Learning: Supervised, Unsupervised, Reinforcement Learning, Applications of Machine Learning in various domains, Steps in Developing Machine Learning Applications	4
2	Data Preprocessing	Importance of Data Preprocessing, Identifying and Handling Missing Data, Feature Scaling – Standardization, Normalization, Robust Scaling, Encoding Categorical Data - Label Encoding, One-Hot Encoding etc.	6
3	Supervised Learning-1	Linear Regression- concepts and model representation, Logistic Regression- concepts and model representation, and Evaluation metrics for linear regression - Mean Absolute Error (MAE), Mean Squared Error (MSE), Root Mean Squared Error (RMSE), R-squared (R^2) Score.	6
4	Supervised Learning-2	Decision trees, random forests, and ensemble methods.	6
5	Unsupervised Learning	Clustering algorithms - K-means, Hierarchical, Dimensionality Reduction – Principal Component Analysis (PCA).	8
Total			30

Textbooks:

1. Peter Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", Cambridge University Press.
2. Hastie, Tibshirani, Friedman, "Introduction to Statistical Machine Learning with Applications in R", Springer, 2nd Edition, 2012
3. Peter Harrington, "Machine Learning in Action", DreamTech Press.

Reference Books:

1. Ethem Alpaydin, "Introduction to Machine Learning"
2. C. M. Bishop, "Pattern Recognition and Machine Learning"

Course Name: Machine Learning Lab

Course Code: PEEC09P

NEP Vertical Basket: PC_PEC

Preamble:

This course is designed to provide students with a comprehensive understanding of fundamental concepts, algorithms, and techniques in machine learning. Through a combination of theoretical lectures, hands-on lab sessions, and real-world projects, students will gain the necessary knowledge and skills to apply machine learning effectively in practical scenarios.

Pre-requisites:

- EC09 (Python Programming)

Course Objectives:

- To understand Machine Learning Concepts.
- To apply various data processing techniques.
- To understand and apply supervised and unsupervised algorithm concepts.
- To apply knowledge of machine learning to solve real-world problems.

Course Outcomes:

CO1: Understand the fundamental concepts and scope of Machine Learning.

CO2: Apply various techniques of Data Preprocessing to clean, transform, and prepare raw data.

CO3: Analyse and interpret the concepts and model representations of Linear Regression and Logistic Regression.

CO4: Compare decision trees, random forests, and ensemble methods for supervised learning.

CO5: Utilize clustering algorithms along with dimensionality reduction techniques to identify patterns and reduce the dimensionality of data.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Scheme:

Head	ISA	MSE	ESE	Total
Practical	25	-	25	50

Suggested List of Practical:

1. Setting up Python environment, introduction to libraries like NumPy, Pandas, and scikit-learn.
2. Hands-on data preprocessing using Python libraries.
3. Implementing regression and classification algorithms.
4. Implementing decision trees and ensemble methods.
5. Implementing clustering and dimensionality reduction techniques.
6. Hands-on projects covering real time applications of machine learning.

Textbooks:

1. Peter Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", Cambridge University Press.
2. Hastie, Tibshirani, Friedman, "Introduction to Statistical Machine Learning with Applications in R", Springer, 2nd Edition, 2012
3. Peter Harrington, "Machine Learning in Action", DreamTech Press.

Reference Books:

1. Ethem Alpaydin, "Introduction to Machine Learning", PHI 2nd Edition, 2013
2. C. M. Bishop, "Pattern Recognition and Machine Learning

Detailed Syllabus of DS Track – Sem V & VI

Course Name: Advanced Database Management System

Course Code: PEEC02T

NEP Vertical Basket: PC_PEC

Preamble:

Mastering on mastering advanced database systems demands a structured approach. Our comprehensive roadmap covers query processing, advanced data management, distributed databases, big data, NoSQL, enhanced data models, and information retrieval. Each module delves into its domain, blending theory with hands-on tasks. This systematic curriculum ensures learners gain a holistic understanding of modern database systems, ready to navigate complex data landscapes.

Pre-requisites:

EC08 - DBMS

Objective:

1. To impart knowledge related to query processing and query optimization phases of a database management system.
2. To learn advanced techniques for data management and to overview emerging data models like Temporal, Mobile, and Spatial database.
3. To introduce advanced database models like distributed databases.
4. To create awareness of how enterprise can organize and analyse large amounts of data by creating a Data Warehouse.
5. To understand the process of data extraction, transformation and loading.
- 6 To understand the concept of Big data and NoSQL databases.
6. To learn different IR models and queries in IR Systems

Course Outcomes:

Learner will be able to:

CO1: Measure query costs and design alternate efficient paths for query execution.

CO2: Apply sophisticated access protocols to control access to the database.

CO3: Design distributed databases for improving resource utilization, availability and performance

CO4: To apply the traits of temporal and spatial data models as per the need

CO5: Perform efficient and effective retrieval of information to facilitate the decision making

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	075

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Query Processing and Optimization	Overview: Introduction, Query processing in DBMS, Steps of Query Processing, Measures of Query Cost Selection Operation, Sorting, Join Operation, Evaluation of Expressions. Query Optimization Overview, Goals of Query Optimization, Approaches of Query Optimization, Transformations of Relational Expression Estimating Statistics of Expression Results Choice of Evaluation Plans. Self-learning Topics: Solve problems on query Optimization	6
2	Access Control Mechanism	Discretionary Access Control Based on Granting and Revoking Privileges. Mandatory Access Control and Role Based Access Control, Remote Database access protocol. Self-learning Topics: Learn Data Security concepts like Authentication, Authorization and encryption.	6
3	Distributed Databases	Introduction: Distributed Data Processing, Distributed Database System: Architecture, Types, Design Issues. Data Fragmentation, Allocation in distributed databases. Self-learning Topics: Query Optimization in Distributed Databases	6
4	Enhanced Data Models	Active Database Concepts and Triggers, Temporal Database, Spatial Database, Introduction to Deductive Databases Self-learning Topics: Case Study like : "Temporal Dynamics in Information Retrieval: Modelling Temporal Relevance and Query Intent Shifts Over Time"	6
5	Introduction to Information Retrieval	Retrieval Models, Types of Queries in IR Systems, Text Preprocessing Self-learning Topics : Case Study like "Information retrieval evaluation in practice"	6
Total			30

Textbooks:

1. Korth, Silberchatz, Sudarshan, : "Database System Concepts", 6th Edition, McGraw – Hill
2. Elmasri and Navathe, "Fundamentals of Database Systems", 6th Edition, PEARSON Education.
3. Theraja Reema, "Data Warehousing", Oxford University Press.
4. Raghu Ramakrishnan and Johannes Gehrke, "Database Management Systems" 3rd Edition - McGraw Hill

References:

1. Paulraj Ponniah, "Data Warehousing: Fundamentals for IT Professionals", Wiley India.
2. Ralph Kimball, Margy Ross, "The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modelling", 3rd Edition. Wiley India.
3. Peter Rob and Carlos Coronel, "Database Systems Design, Implementation and Management", Thomson Learning, 9th Edition

Course Name: Advanced Database Management System Lab

Course Code: PEEC02P

NEP Vertical Basket: PC_PEC

Preamble:

The Advanced Database Laboratory immerses students in leading-edge database technologies and advanced concepts, expanding upon foundational knowledge from prerequisite courses. Through hands-on exploration, students delve into topics including NoSQL databases, distributed data management, query processing and optimization, and advanced SQL techniques. Practical exercises and projects facilitate a deeper understanding of database design, optimization, and administration. Additionally, students gain valuable insights into emerging trends and challenges within the dynamic realm of database management.

Pre-requisites:

EC08 - DBMS

Objective:

- Mastering Conceptual DB Design using EER Model and implementing it using SQL DDL
- Explore advanced SQL concepts
- Gain practical experience in working with distributed databases, temporal data bases, spatial data bases and active databases and proposing a solution using appropriate model(s).
- Learn how to integrate PHP scripts with MySQL databases to create dynamic web applications.
- Develop proficiency in designing, implementing, and optimizing complex database systems for real-world applications and interface a database with front end tools
- Apply best practices in database administration, security, and scalability to ensure robust and efficient database systems.

Course Outcomes:

Learner will be able to:

CO1: Students will be able to design database schemas using EER model techniques and implement them using SQL.

CO2: Students will demonstrate proficiency in writing advanced SQL queries and understand query optimization principles.

CO3: Students will develop skills in accessing and manipulating databases through JDBC in Java programs.

CO4: Students will understand query evaluation plans, indexing strategies, and their impact on database performance.

CO5: Students will implement distributed database solutions, including partitioning strategies, for scalability and performance.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Practical	25	-	25	50

Suggested list of experiments:

Sr. No.	List of experiments
1	Design EER Model for a real-life scenario and implement it using SQL
2	Understand and compare performance by rewriting queries using indexing
3	Implement the Program to estimate cost of the query for various join operation
4	Build Web Applications with access control features
5	Explore the security and access control features of PostgreSQL (or equivalent system)
6	Implementation of fragmentation in distributed database environment.
7	Implementation of triggers for understanding features of active database
8	Design a temporal and spatial data base schema , map it to tables and solve queries involving temporal and spatial attributes

Textbooks:

1. Ramez Elmasri, Shamkant B. Navathe, "Fundamentals of Database Systems", 4th Edition, Pearson/Addison wesley, 2007
2. Abraham Silberschatz, Henry F. Korth, S. Sudharshan, "Database System Concepts", 6th edition, Tata McGraw Hill, 2011

Reference Books:

1. T. Özsu and P. Valduriez, Distributed Database Systems. Prentice Hall, Oct. 2011. [ISBN: 013616736X]
2. NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence" by Martin Fowler and Pramod J. Sadalage

Course Name: Data Warehousing & Mining

Course Code: PEEC06T

NEP Vertical Basket: PC_PEC

Preamble:

In today's data-driven world, organizations rely heavily on data warehousing and data mining techniques to extract meaningful insights from large volumes of data. This course aims to provide learners with a comprehensive understanding of the foundational principles of data warehousing and basic concepts of data mining. Through theoretical exploration, participants will gain insights into the design, implementation, and administration of data warehouses, as well as the fundamental techniques and applications of data mining.

Pre-requisites:

EC22T - Advance Database Management Systems

Course Objectives:

- Understand the fundamental concepts and historical development of data warehousing.
- Gain insights into the design principles and architecture of data warehouses.
- Explore the processes involved in ETL (Extract, Transform, Load) in data warehousing.
- Understand the fundamental concepts and architecture of data lakes as centralized repositories for storing and processing diverse data types.
- Familiarize oneself with basic concepts and techniques of data mining, including preprocessing, model building, and evaluation.
- Explore the various methods and applications of data mining in real-world scenarios.

Course Outcomes:

On successful completion, of course, learner/student will be able to:

CO1: Demonstrate a comprehensive understanding of the fundamental concepts of data warehousing and its architecture.

CO2: Design a data warehouse schema using dimensional modeling techniques and explain the ETL process involved in data warehousing.

CO3: To introduce concepts and fundamentals of data lakes

CO4: Understand data mining principles and perform data preprocessing and Visualization.

CO5: Understand the concept of data mining and identify appropriate data mining algorithms to solve real-world problems.

CO6: Implement basic data mining algorithms such as classification, clustering, and association mining

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	75

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to data warehouse and ETL Process	Introduction to Data Warehouse and Data Mart , Data warehouse architecture, Data warehouse vs Data Marts Dimensional modeling, Design of information package, star schema, snowflake schema, fact constellation schema, factless fact tables, aggregate fact tables. OLAP operations ETL process: Basic steps of the ETL process, different extraction methods, transformations, and different loading techniques.	8
2	Introduction to Data Lakes	Definition, key attributes of data lake, challenges, functionalities, architecture, Curating data lakes, Data Lake vs. data warehouse	3
3	Data Exploration and Data Preprocessing	The KDD process, Data mining system architecture, Data Exploration: Types of Attributes, Statistical Description of Data, Data Visualization: box plots, line & bar charts, and scatter plots. Data Preprocessing: Descriptive data, summarization, Cleaning, Integration & transformation, Data reduction.	5
4	Classification	Introduction to data mining techniques, Classification: Decision Tree Induction, Naïve Bayesian Classification. Regression: Simple and multiple	5
5	Clustering	Clustering: Partition based: K-means, Hierarchical Methods (Agglomerative, Divisive).	4

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6	Mining frequent patterns and associations	Basic Concepts: Market Basket Analysis, Frequent Itemset, Closed Itemset, and Association Rules; Frequent Itemset. Mining Methods: The Apriori Algorithm: Finding Frequent Itemset Using Candidate Generation, Generating Association Rules from frequent Itemset, Improving the Efficiency of Apriori, A pattern growth approach for mining Frequent Itemset, Mining Frequent Itemset using vertical data formats.	5
Total			30

Textbooks:

3. Margy Ross and Ralph Kimball, "The Data Warehouse Toolkit", 3rd edition, Willey
4. Paulraj Ponniah, "Data Warehouse Fundamentals", Wiley-Interscience Publication
5. Bill Inmon, "Data Lake Architecture", 1st edition, Technics Publication
6. Jiawei Han, Micheline Kamber, Jian Pei, "Data Mining Concepts and Techniques", 3rd edition, Elsevier

Reference Books:

1. W. H. Inmon, "Building the Data Warehouse", 3rd edition, Wiley Computer Publishing

Course Name: Data Warehousing & Mining Lab

Course Code: PEEC06P

NEP Vertical Basket: PC_PEC

Preamble:

In today's data-driven world, organizations rely heavily on data warehousing and data mining techniques to extract meaningful insights from large volumes of data. This course aims to provide learners with a comprehensive understanding of the foundational principles of data warehousing and basic concepts of data mining. Through hands-on exploration, learners will gain insights into the design and implementation of data warehouses, as well as the fundamental techniques and applications of data mining.

Pre-requisites:

EC22P – Advance Database Management Systems Lab

Course Objectives:

- Understand and design the concepts of star, snowflake, and galaxy schemas for efficient data organization in data warehouses.
- Understand and execute complex queries and apply OLAP operations effectively.
- Understand various preprocessing and visualization techniques.
- Apply regression techniques and classification algorithms to analyze data, predict outcomes, and gain valuable insights.
- Implement clustering algorithms to effectively group data based on similarities, facilitating improved data organization and analysis.
- Apply association rule mining techniques to identify and analyze patterns and relationships between variables in large datasets.

Course Outcomes:

Learner will be able to:

CO1: Develop and design star, snowflake, and galaxy schemas for data warehouses.

CO2: Execute complex queries and perform Online Analytical Processing (OLAP) operations to analyze data.

CO3: Apply various data preprocessing and visualization techniques to effectively communicate data insights and patterns.

CO4: Implement regression techniques and classification algorithms to analyze data, predict outcomes, and gain valuable insights in practical scenarios.

CO5: Implement clustering algorithms to group data based on similarities.

CO6: Implement association rule mining techniques to identify and analyze patterns and relationships

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Practical	25	-	25	050

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall decide her/his assessment methodology based on the course's nature. Faculty may propose a revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Suggested list of experiments:

Sr. No.	List of experiments	Concept
1	Design Information Package, Star Schema & Snowflake Schema	Data Warehouse schema design
2	DW queries & OLAP operations	OLAP
3	Apply different visualization techniques	Data Visualization
4	To implement linear regression (Simple & Multiple) -Python	Regression analysis
5	To implement the ID3 decision tree algorithm – rapid miner and Weka	Classification
6	To implement Naïve Bayes classifier(python)	Classification
8	To implement the K-means clustering algorithm – weka and Rapidminer	Clustering
9	To implement Agglomerative clustering algorithm -python	Clustering
10	To implement the Apriori algorithm – Weka and RapidMiner	Association Analysis

Course Name: Probabilistic Graphical Model

Course Code: PEEC10T

NEP Vertical Basket: PC_PEC

Preamble:

Probabilistic graphical models (PGMs) are a powerful framework that combines probability theory and graph theory to represent and reason about uncertainties in complex systems. They use graphs to encode the conditional dependencies between random variables, facilitating efficient computation of joint distributions and marginal probabilities. PGMs include various models such as Bayesian networks, which utilize directed acyclic graphs, and Markov networks, which employ undirected graphs to represent relationships. These models are widely used in fields like machine learning, artificial intelligence, and bioinformatics for tasks such as prediction, diagnostics, and decision-making under uncertainty.

Pre-requisites:

All Engineering Mathematics & Machine Learning

Course Objectives:

- Understand the principles of probability including random variables, distributions, expectation, and variance, to model and analyze uncertainty in various contexts.
- Understand the fundamental concepts and algorithms of graph theory, enabling the analysis and optimization of networks and relational structures.
- Learn to construct and use Bayesian networks for representing probabilistic dependencies, performing inference, and making data-driven decisions.
- Understand and apply Markov network models to capture and analyze local dependencies in undirected graphs for complex system modeling.
- Gain proficiency in modeling and analyzing sequential and time-series data using Hidden Markov Models.
- Explore practical applications of probabilistic graphical models across machine learning, artificial intelligence, and bioinformatics, developing skills to solve real-world problems.

Course Outcomes:

Learner will be able to:

CO1: Understand the basic concepts of Probability theory and Graph theory.

CO2: Learn and apply Bayesian networks for representing probabilistic dependencies, performing inference, and making data-driven decisions.

CO3: Understand and utilize Markov network models to represent joint distributions and local dependencies, enhancing their analytical skills for complex systems.

CO4: Gain proficiency in modeling and analyzing sequential and time-series data using Hidden Markov Models,

CO5: To make inferences, learning, actions and decisions while applying probabilistic models.

CO6: Represent real world problems using graphical models; design inference algorithms; and learn the structure of the graphical model from data.

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Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	--	2	--

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	075

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to Probability & Graph Theory	Introduction to Probability Theory: Probability Theory, Basic Concepts in Probability, Probability Axioms and Properties, Conditional Probability and Independence, Discrete Random Variables: Binomial, Poisson, Continuous Random Variables: Uniform, Normal, Continuous Spaces, Expectation, Variance and Covariance. Introduction to Graphs: Graph Definitions and Types, Graph Representation: Adjacency Matrix and List, Subgraphs, Paths and Trails, Cycles and Loop.	4
2	Bayesian Network Model and Inference	Directed Graph Model: Bayesian Network-Structure and Semantics, Exploiting Independence Properties, Naive Bayes Model, Bayesian Network Model, Basic Independencies in Bayesian Networks, Conditional Independence and d-Separation, Bayesian Network Semantics, Graphs and Distributions. Exact inference: Variable Elimination, Conditioning, CPD's and its types, Inference with Structured CPDs.	6
3	Markov Network Model and Inference	Undirected Graph Model: Markov Model-Structure and Components of Markov Networks, Parameter Estimation Techniques, Gibb's distribution, Reduced Markov Network, Markov Network Independencies.	6

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		Exact inference variable elimination: Graph Theoretical Analysis for Variable Elimination, Conditioning.	
4	Hidden Markov Model and Inference	Structure of HMM: States, Observations, Probabilities, Template Based Graph Model: HMM- Temporal Models, Template Variables and Template Factors, Directed Probabilistic Models, Undirected Representation, Structural Uncertainty.	6
5	Learning and Taking Actions and Decisions	Learning Graphical Models: Goals of Learning, Density Estimation, Specific Prediction Tasks, Knowledge Discovery. Learning as Optimization: Empirical Risk, over fitting, Generalization, Evaluating Generalization Performance, selecting a Learning Procedure, Goodness of fit, Learning Tasks. Parameter Estimation: Maximum Likelihood Estimation, MLE for Bayesian Networks. Causality: Conditioning and Intervention, Correlation and Causation, Causal Models, Structural Causal Identifiability, Mechanisms and Response Variables, Learning Causal Models. Utilities and Decisions: Maximizing Expected Utility, Utility Elicitation. Structured Decision Problems: Decision Tree.	6
6	Applications	Application of Bayesian Networks: Classification, Forecasting, Decision Making. Application of Markov Models: Cost Effectiveness Analysis, Relational Markov Model and its Applications, Application in Portfolio Optimization. Application of HMM: Speech Recognition, Part of Speech Tagging, Bioinformatics.	2
Total			30

Textbooks:

1. Daphne Koller and Nir Friedman, "Probabilistic Graphical Models: Principles and Techniques",
2. Cambridge, MA: The MIT Press, 2009 (ISBN 978-0-262-0139- 2).
3. David Barber, "Bayesian Reasoning and Machine Learning", Cambridge University Press, 1st edition, 2011.
4. Martin Wainwright and Michael Jordan, M., "Graphical Models, Exponential Families, and Variational Inference", 2008.

Reference books:

1. Finn Jensen and Thomas Nielsen, "Bayesian Networks and Decision Graphs (Information Science and Statistics)", 2nd Edition, Springer, 2007.
2. Kevin P. Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012.

Course Name: Probabilistic Graphical Model Lab

Course Code: PEEC10P

NEP Vertical Basket: PC_PEC

Preamble:

In PGM practical sessions, students will delve into the fundamental concepts and applications of probability theory, graph theory, Bayesian networks, Markov networks, and hidden Markov models. Through hands-on exercises and projects, they will gain proficiency in simulating probabilistic outcomes, implementing graph algorithms for traversal and optimization, constructing Bayesian networks from data, performing inference in Markov networks, and decoding sequences using hidden Markov models. These practical's aim to bridge theoretical understanding with practical skills, equipping students with the tools to analyze real-world data, model complex systems, and make informed decisions in uncertain environments

Pre-requisites:

Skill Based Lab-Python Programming

Course Objectives:

- Implement simulations and analyze real-world data to understand and apply fundamental probabilistic concepts.
- Apply graph algorithms to solve optimization problems and analyze network structures in various applications.
- Construct Bayesian networks & Markov Network models from data and perform probabilistic inference for decision-making under uncertainty.
- Implement sequence analysis algorithms to decode hidden states and apply HMMs in pattern recognition tasks.

Course Outcomes:

Learner will be able:

CO1: To simulate and analyze probabilistic phenomena, applying statistical methods to real-world data. CO2: To apply graph algorithms to solve problems in connectivity, shortest paths, and network flows, demonstrating analytical skills in network analysis.

CO3: Evaluate Bayesian networks from data, performing probabilistic inference and decision analysis in uncertain environments.

CO4: Use factor graphs and inference algorithms to model and analyze complex probabilistic relationships in data.

CO5: Implement algorithms for sequence analysis, decode hidden states using HMMs, and apply them in tasks such as speech recognition and biological sequence analysis.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

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Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Practical	25	-	25	050

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose a revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Suggested List of Practical's:

Sr No.	Title of Practical's
1	Experiment on Probability Theory
2	Experiment on Graph Theory
3	Experiment on Bayesian Network Modelling
4	Experiment on Markov Chain Modeling
5	Experiment on HMM
6	Experiment on Maximum Likelihood Estimation
7	Experiment on Decision Making using Decision Trees
8	Experiment on Learning with Optimization

Detailed Syllabus of IoT Track – Sem V & VI

Course Name: Modern Sensors for Internet of Things

Course Code: PEEC03T

NEP Vertical Basket: PC_PEC

Preamble:

This course introduces students to the fundamental principles and applications of sensors in various engineering fields. It covers different types of sensors, their working mechanisms, and their integration into systems, including IoT, embedded systems, and other fields.

Pre-requisites: Nil

Course Objectives:

- Understand the basic principles and classifications of sensors.
- Learn about various types of sensors and their applications.
- Design and implement sensor systems in practical scenarios.
- Integrate sensors with IoT and embedded systems.
- Explore the use of sensors in biomedical applications

Course Outcomes:

Student will be able to:

CO1: Understand fundamentals of Sensors and their characteristics.

CO2: Use different type sensors in Embedded and IoT applications.

CO3: Apply knowledge of conditioning in the design of data acquisition system.

CO4: Create a small sensor network using knowledge of communication protocols.

CO5: Understand concept of communication protocols.

CO6: Designing small applications using one or more sensor.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head	ISA	MSE	ESE	Total
Theory	15	20	40	075

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module no	Module name	Content	No of Hours
1	Sensors Fundamentals and Characteristics	Sensor Classification, Physical Principles of Sensors- Resistive, capacitive, inductive sensors, Optical, magnetic, and thermal sensors, Sensor Characteristics, Performance and Types, Error Analysis characteristics- Sensitivity, accuracy, precision, range, and resolution. Response time and stability, Applications in various fields and criteria to select sensor	5
2	Types of sensors	Optical Sensors- Photodetectors and phototransistors, Fiber optic sensors, Imaging sensors. Mechanical Sensors- Strain gauges and pressure sensors, Accelerometers and gyroscopes, Ultrasonic sensors. Chemical and Biological Sensors- Electrochemical sensors, gas sensors, humidity and temperature sensors, Biosensors	6
3	Data acquisition and Signal Conditioning	Analog and Digital data acquisition system, Data logger, Amplification, filtering, and Analog-to-Digital conversion, Noise reduction techniques, Calibration methods	5
4	Wireless Sensor Networks	Basics of wireless communication, Network topologies and protocols, Bluetooth, ZigBee, Ultra Wide Band (UWB), Near Field Communication (NF) and RFID, WiFi and IEEE 802.11 architecture, applications in IoT.	6
5	IoT Systems and Integration and communication protocols	Introduction to IoT, Integrating sensors with microcontrollers (e.g., Arduino, Raspberry Pi), Communication protocols (I2C, SPI, UART),	4
6	Sensor applications	On board automobile sensing system, Home automation and Environment monitoring system, Biomedical sensing system, Radio sensing for industrial applications,	4
Total			30

Textbooks:

1. Jacob Fraden, "Hand Book of Modern Sensors: physics, Designs and Applications", 2015, 3rd edition, Springer, New York.
2. Jon. S. Wilson, "Sensor Technology Hand Book", 2011, 1st edition, Elsevier, Netherland
3. D. Patranabis – Sensor and Transducers (2e) Prentice Hall, New Delhi, 2003
4. Vijay Madiseti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", 1st Edition, VPT, 2014
5. Sensors and Transducers" by Ian R. Sinclair - Comprehensive introduction to various sensors and their applications.

Reference Books:

1. Edited by Qusay F Hasan, Atta ur rehman Khan, Sajid A madani, "Internet of Things Challenges, Advances, and Application", CRC Press
2. Triethy HL - Transducers in Electronic and Mechanical Designs, Mercel Dekker, 2003
3. Gerd Keiser, "Optical Fiber Communications", 2017, 5th edition, McGraw-Hill Science, Delhi. 212

4. John G Webster, Halit Eren, "Measurement, Instrumentation and sensor Handbook", 2014, 2nd edition, CRC Press, Taylor and Fransis Group, New York.
5. Adrian McEwen, "Designing the Internet of Things",Wiley Publishers, 2013, ISBN: 978-1-118-43062-0
6. Nathan Ida, "Sensors, Actuators and their Interfaces: A Multidisciplinary Introduction", Second Edition, IET Control, Robotics and Sensors Series 127, 2020

Course Name: Modern Sensors for Internet of Things Lab

Course Code: PEEC03P

NEP Vertical Basket: PC_PEC

Preamble:

This course introduces students to different types of sensors, their working mechanisms, and their integration into systems. Selection and interfacing of a sensor in the IoT and embedded systems design.

Pre-requisites: Nil

Course Objectives:

- To understand various sensors type and their characteristics.
- To understand different type of sensors and their application.
- To understand communication protocol and their use in sensor network.
- To understand various types communication protocols required in IoT applications and their characteristics.
- To learn to develop small IoT or Embedded system using sensor.

Course Outcomes:

Student will be able to:

CO1: Identify and test the characteristics of various sensors.

CO2: Select most appropriate sensor and design required signal condition for the same.

CO3: Implement communication and wireless communication protocol in IoT application.

CO4: Design and implement small IoT or Embedded system.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Scheme:

Head	ISA	MSE	ESE	Total
Practical	25	-	25	050

Suggested List of Practical:

- Identification of sensor and their important characteristics.
- Testing and Calibration of sensor.
- Identification of Sensitivity, range, resolution, Response time parameters of sensors
- Develop a system to record one of the physical parameter using appropriate sensor
- Develop a system to communicate one or more physical parameters using wireless

communication.

- Develop a system to communicate one or more physical parameters using communication protocol.
- Design and develop a small IoT or system using one or more sensor and a communication protocol.

Textbooks:

1. Jacob Fraden, "Hand Book of Modern Sensors: physics, Designs and Applications", 2015, 3rd edition, Springer, New York.
2. Jon. S. Wilson, "Sensor Technology Hand Book", 2011, 1st edition, Elsevier, Netherland
3. D. Patranabis – Sensor and Transducers (2e) Prentice Hall, New Delhi, 2003
4. Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", 1st Edition, VPT, 2014
5. Sensors and Transducers" by Ian R. Sinclair - Comprehensive introduction to various sensors and their applications.

Reference Books:

1. Edited by Qusay F Hasan, Atta ur rehman Khan, Sajid A madani, "Internet of Things Challenges, Advances, and Application", CRC Press
2. Triethy HL - Transducers in Electronic and Mechanical Designs, Mercel Dekker, 2003
3. Gerd Keiser, "Optical Fiber Communications", 2017, 5th edition, McGraw-Hill Science, Delhi. 212
4. John G Webster, Halit Eren, "Measurement, Instrumentation and sensor Handbook", 2014, 2nd edition, CRC Press, Taylor and Fransis Group, New York.
5. Adrian McEwen, "Designing the Internet of Things", Wiley Publishers, 2013, ISBN: 978-1-118-43062-0
6. Nathan Ida, "Sensors, Actuators and their Interfaces: A Multidisciplinary Introduction", Second Edition, IET Control, Robotics and Sensors Series 127, 2020

Course Name: Principles of Internet of Things

Course Code: PEEC07T

NEP Vertical Basket: PC_PEC

Preamble:

The world around us is becoming increasingly interconnected. Internet of Things (IoT), a rapidly evolving field that's transforming the way we live, work, and interact with the world around us. This course will be your deep dive into the foundations of IoT. Students will delve into the language of sensors and actuators, uncover the secrets of communication between devices, and understand the challenges and opportunities that come with a connected world. By the end, students will gain a solid understanding of the fundamental building blocks of IoT and be well-equipped to navigate this exciting and ever-growing field. Students will also be able to build use cases and Mini projects

Pre-requisites:

- C Programming
- Object Oriented Programming
- Microprocessor and Microcontroller

Course Objectives:

- To Understand the core concepts of the Internet of Things (IoT) and its key components & Levels.
- To Explore different Protocols used in IoT Communication
- To Gain a foundational knowledge of common IoT Interfaces.
- To Develop critical thinking skills to analyze proper selection of Boards
- To build practical skills by programming or building a simple IoT project to solidify your understanding.

Course Outcomes:

Student will be able to:

CO1: Understand the concept of IoT and its key components of IoT.

CO2: Understand different IoT Communication Protocols.

CO3: Understand different hardware Communication Protocols.

CO4: Select appropriate development boards for Building IOT Applications.

CO5: Develop programs for IoT application.

CO6: Develop creative applications of IoT technology in chosen fields.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	15	20	40	75

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction to Internet of Things	1.1 Definition and characteristics of IoT 1.2 History and evolution of IoT 1.3 Architectural layers of an IoT system (perception, network, application, data management) 1.4 Levels of IoT	5
2	Communication Protocols	2.1 IoT Edge to Cloud protocols: HTTP, REST APIs, WebSocket, MQTT, COAP, Comparison of Protocols.M2M Communication Protocols, 2.2 Bluetooth BR/EDR and Bluetooth low energy. RFID IoT System , RFID IoT Network Architecture, ZigBee IP/ZigBee SE2.0, Wifi(WLAN), 2.3 Message Communication protocols for connected devices Data exchange formats: JSON & XML	5
3	Sensor Interfaces	3.1 Digital Interfaces: UART, Serial Peripheral Interface (SPI), I2C (Inter-Integrated Circuit), Controller Area Network (CAN), Middleware Technologies, 3.2 Communication Protocols and Models. Practical Components Programming with interface in Arduino, MBed and Raspberry Pi	5
4	Hardware Fundamentals	4.1 Introduction to various sensors (temperature, humidity, pressure, motion, etc.) 4.2 Actuators and their types (solenoids, motors, relays) 4.3 Microcontrollers and development boards (e.g., Arduino, Raspberry Pi) 4.4 Interfacing sensors and actuators with microcontrollers 4.5 Introduction to embedded system design principles	5
5	Software Development for IoT	5.1 Introduction to programming languages for IoT (e.g., Python, C++) 5.2 Data acquisition, processing, and visualization techniques 5.3 Introduction to IoT platforms and frameworks Security considerations in IoT applications	5
6	IOT Applications and USE Cases	Case Studies Illustrating IoT Design in Applications like Home Automation, Smart Cities, Environment, Agriculture, Healthcare.	5
Total			30

Textbooks:

1. ArshdeepBahga and Vijay Madisetti, "Internet of Things: A Hands-on Approach, Universities Press.
2. Raj Kamal, "Internet of Things: Architecture and Design Principles", McGraw Hill Education, First edition

Reference Books:

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry,"IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things
2. N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014.

Course Name: Principles of Internet of Things Lab

Course Code: PEEC07T

NEP Vertical Basket: PC_PEC

Preamble:

This lab will describe the market around the Internet of Things (IoT), the technology used to build these kinds of devices, how they communicate, how they store data, and the kinds of distributed systems needed to support them

Pre-requisites:

- C Programming
- Object Oriented Programming
- Microprocessor and Microcontroller

Course Objectives:

- To Understand interfacing of Sensors & actuators
- To identify how IoT differs from traditional data collection systems.
- To explore the interconnection and integration of the physical world and able to design & develop IOT Devices.

Course Outcomes:

Student will be able to:

CO1: Adapt different techniques for data acquisition using various IoT sensors for different applications.

CO2: Demonstrate the working of actuators based on the collected data.

CO3: Use different IoT simulators and correlate working of IoT protocols.

CO4: Select appropriate development board for IoT application.

CO5: Implement IoT protocols like MQTT for communication to realize the revolution of internet in mobile devices, cloud and sensor networks.

CO6: Develop use cases for Different IoT Applications.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Practical	25	-	25	50

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Suggested List of Practical's:

1. To study and implement interfacing of different IoT sensors with Raspberry Pi/Arduino/NodeNCU
2. To study and implement interfacing of actuators based on the data collected using IoT sensors. (like led switch ON/OFF, stepper word)Modulation and Demodulation of Binary Frequency Shift Keying.
3. To study and demonstrate use of IoT simulators (like Beviswise) on any real time device (LED/stepper motor)
4. To study MQTT Mosquitto server and write a program on Arduino/Raspberry Pi to publish sensor data to MQTT broker.
5. Interfacing to Wireless Communication Devices like Bluetooth , LoRA
6. Install OS in Raspberry Pi
7. Predictive Maintenance in Industrial Automation Systems
8. Study different hardware Boards used in IoT applications

Mini Projects / Case Study :-

Select any one case study (in a group of 2-3) and perform the experiments 5 to 10. The sample case studies can be as follows:

1. Smart home automation system
2. Healthcare management system
3. Smart traffic management system & so on...
4. Write a program on Raspberry Pi to push and retrieve the data from cloud like thing speak, things board, AWS, Azure etc.

Textbooks / Reference Books

1. Jake VanderPlas, "Python Data Science Handbook", O'Reilly publication, 2016
2. Joakim Verona," Practical DevOps", PACKT publishing, 2016
3. Honbo Zhou," The internet of things in the cloud", CRC press, Taylor and Francis group, 2012
4. Perry Lea," Internet of things for architects", PACKT publishing, 2018

Course Name: Embedded System Design with Tiny Operating System (OS)

Course Code: PEEC11T

NEP Vertical Basket: PC_PEC

Preamble:

Embedded System is used for developing a dedicated task or application. Internet of Things (IoT) is an upcoming technology based on the base of embedded systems. Machine learning (ML) is also an upcoming technology and concepts of ML are used in many applications. This course blends the concepts of embedded systems with machine learning for developing smart and dedicated applications for requirements of IoT. It introduces the fundamental concepts of operating systems and use of operating system in the development of embedded systems.

Pre-requisites:

- C Programming
- Object Oriented Programming
- Microprocessor and microcontroller

Course Objectives:

- To understand the fundamentals of ARM 7 family.
- To understand concepts of embedded systems.
- To understand communication interface for embedded systems.
- To understand working with Real Time Operating Systems (RTOS).
- To understand fundamental concepts of tiny machine learning.
- To use tiny machine learning for embedded systems.

Course Outcomes:

Student will be able to:

CO1: Understand fundamental concepts of advanced 32 bit micro-controllers.

CO2: Demonstrate the fundamental concepts of embedded system design

CO3: Use communication interface for design of embedded system.

CO4: Understand concept of Real Time Operating Systems (RTOS) for embedded system design.

CO5: Understand fundamental concepts of tiny machine learning.

CO6: Use concept of tiny machine learning for design of embedded systems.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	2	2	1

Assessment Guidelines:

Head	ISA	MSE	ESE	Total (Passing @40% of total)
Theory	15	20	40	075

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module no	Module name	Content	No of Hours
1	ARM 7 family and Programming	Introduction, features, basic architecture, Cortex family, register organization with different registers like CPSR	6
2	Introduction to embedded systems	Introduction and different examples/applications, classification of embedded systems, design metrics of an embedded systems, embedded system design life cycle, processor technology for embedded systems, concept of modelling in embedded systems	5
3	Communication Protocols for embedded systems	UART, SPI, I2C, CAN with details like pins, working, timing diagram and common applications, introduction to other communication protocols like zig-bee and Wi-Fi.	6
4	Real Time Operating Systems	Basic concept of operating system, process management with scheduling and related issues, process synchronization with algorithms, concept of threading	6
5	Machine Learning Fundamentals	Concept of machine learning, fundamentals of tiny ML, design and challenges, Building and training machine learning model, Convolutional Neural Networks	4
6	Application Development	Building applications and deployment of model	3
Total			30

Textbooks:

1. Embedded System Architecture, Programming & Design (Tata McGraw Hill Publication, Third Edition)- Raj Kamal
2. An Embedded Software Primer- David E. Simon
3. Embedded Real Time Systems Programming- Sriram V. Iyer, Pankaj Gupta
4. MicroC/OS-II, Indian Low price Edition 2002- Jean J. Labrose
5. Embedded Real Time Systems: Concepts, design & Programming (Dreamtech Publication)- K. V. K. K. Prasad

Reference Books:

1. Embedded System Design: A Unified Hardware/Software Introduction (Wiley Publication)- frank Vahid, Tony Givargis
2. ARM System-on-Chip Architecture (Pearson 2005)- Steve Furber
3. Tiny Machine Learning - Pete Warden and Daniel Situnayake
4. Rajib Mall: "Real Time Systems theory and practice", Pearson 2008

Assessment:

1. **ISA (In-Semester-Assessment):** In semester assessment will carry total 15 marks. It will consist of weekly graded assignments based on modules (each carrying 10 marks). The assignments are self-study work and need to be completed by individual students separately. Every student will be submitting four completed assignments. Students are encouraged to develop their own problem statements and devise a proper method / solution. Importance will be given to the concept understanding and applying it to solve the industrial problem using coding.
2. **MSA (Mid-Semester-Assessment):** Mid Semester Assessment will consist of three mid semester internal theory test carrying 20 marks based on completion of minimum modules. This test will be common for all the students. ***Repeat examination will not be conducted.***
3. **ESE (End-Semester-Examination):** End Semester Examination will be conducted for total of 40 marks based on the completion of remaining modules post completion of mid semester examination or an entire syllabus. This test will be common for all the students.

Course Name: Embedded System Design with Tiny Operating System (OS) Lab

Course Code: PEEC11P

NEP Vertical Basket: PC_PEC

Preamble:

Embedded System is a used for developing a dedicated task or application. Internet of Things (IoT) is an upcoming technology based on the base of embedded systems. Machine learning (ML) is also an upcoming technology and concepts of ML are used in many applications. This course enables learner to use concept of tiny machine learning and Real Time Operating System for design of embedded systems.

Pre-requisites:

- C Programming
- Object Oriented Programming
- Microprocessor and microcontroller

Course Objectives:

- To understand the fundamentals of ARM 7 family.
- To understand concepts of embedded systems.
- To understand communication interface for embedded systems.
- To understand working with Real Time Operating Systems (RTOS).
- To understand fundamental concepts of tiny machine learning.
- To use tiny machine learning for embedded systems.

Course Outcomes:

Student will be able to:

CO1: Use concepts of advanced 32 bit micro-controllers.

CO2: Apply the fundamental concepts of embedded system design.

CO3: Use communication interface for design of embedded system.

CO4: Use Real Time Operating Systems (RTOS) for embedded system design.

CO5: Use fundamental concepts of tiny machine learning.

CO6: Apply concept of tiny machine learning for design of embedded systems.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Scheme:

Head	ISA	MSE	ESE	Total
Practical	25	-	25	25

Suggested List of Practical:

All practical will be project based with focus on following application

1. Smart population count system
2. Smart traffic light system
3. Smart temperature monitoring system
4. E notice board
5. E display
6. Smart elevator system

Textbooks:

1. Embedded System Architecture, Programming & Design (Tata McGraw Hill Publication, Third Edition)- Raj Kamal
2. An Embedded Software Primer- David E. Simon
3. Embedded Real Time Systems Programming- Sriram V. Iyer, Pankaj Gupta
4. MicroC/OS-II, Indian Low price Edition 2002- Jean J. Labrose
5. Embedded Real Time Systems: Concepts, design & Programming (Dreamtech Publication)- K. V. K. K. Prasad

Reference Books:

1. Embedded System Design: A Unified Hardware/Software Introduction (Wiley Publication)- frank Vahid, Tony Givargis
2. ARM System-on-Chip Architecture (Pearson 2005)- Steve Furber
3. Tiny Machine Learning - Pete Warden and Daniel Situnayake
4. Rajib Mall: "Real Time Systems theory and practice", Pearson 2008

Assessment: In-Semester-Assessment (25 Marks)

1. ***All the students are required (mandatory) to be present in person during the laboratory conduction session.*** The ISA will consist of awarding marks for the complete, successful and in time submission of minimum 10 dually graded experiments (project based).
2. ***Project prototype to be developed and demonstrated.***
3. ***Graded marks for 10 experiments will be converted to ISA marks of 25. Only one repeat session is allowed to cover up the missed lab session.***
4. Students will be awarded grade / or marks on each experiment based on his / her own contribution, showcasing the knowledge application skills, demonstrating measurement work, developing code / solution to the given problem and peer interaction.
5. ***Student will lose the marks if he or she remains absent for the Laboratory P***

Detailed Syllabus of VLSI Track – Sem V & VI

Course Name: Digital System Design

Course Code: PEEC04T

NEP Vertical Basket: PC_PEC

Preamble:

Digital System design is a study of Programmable Logic Devices, Sequential Circuit Design, Introduction to VERILOG, Levels of Abstraction on VERILOG, and Design of Combinational and Sequential Circuits. This course aims to equip students with the necessary theoretical knowledge and practical skills required in the field of digital logic design and hardware description languages. Through a combination of theoretical lectures, practical demonstrations, and hands-on exercises, students will develop a comprehensive understanding of digital logic design principles and gain proficiency in using hardware description languages for circuit design and simulation.

Pre-requisites:

- Digital Electronics
- Electronic Devices and circuits.
- Basic of VLSI Design

Course Objectives:

- To explore the classification, concepts, and implementation of Programmable Logic Devices (PLDs)
- To learn about the building blocks of synchronous and asynchronous sequential circuits.
- To introduced to VERILOG, a hardware description language widely used in digital design.
- Design various Combinational and Sequential circuits using VERILOG.

Course Outcomes:

CO1: Design hardware that can be implemented on a variety of Programmable Logic Devices.

CO2: Design different sequential circuits using Finite state machine.

CO3: Understand basic entities of Verilog HDL.

CO4: Use various abstraction levels of Verilog HDL for a given application.

CO5: Design the combinational and sequential logic circuits using various constructs in Verilog

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	15	20	40	075

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Unit No.	Content	Hrs.
1		Programmable Logic Devices.	4
	1.1	Classification of Programmable Logic Devices, Concept and Implementation of PROM, PLA, and PAL. CPLD and FPGA	
	1.2	Block diagram of CPLD, General Structure of FPGA, Introduction to XILINX FPGA family.	
2		Sequential Circuit design using state machines.	8
	2.1	Building blocks of Synchronous and Asynchronous sequential circuits. General Model of Synchronous Sequential circuit, Moore, and Mealy Circuits.	
	2.2	Analysis Synchronous and Asynchronous sequential circuits: State Table, State diagram, state equation, state reduction, state assignment and logic realization Design of synchronous sequential circuits using various flip flops.	
3		Introduction to VERILOG.	4
	3.1	Lexical Conventions, Methodology: Top Down & Bottom Up Modules, Data types, Arrays, Ports, Variables and Constants, Operator types, Functions and Tasks, Test Bench.	
	3.2	VERILOG Primitives. VERILOG Language formal syntax	
4		Levels of Abstraction on VERILOG	6
	4.1	Gate-Level Modelling: Modelling using basic Verilog gate primitives, description of and/or and buff/not type gates, rise, fall and turn-off delays, min, max, and typical delays.	
	4.2	Dataflow Modelling: Continuous assignments, delay specification, expressions, operators, operands, operator types.	
	4.3	Behavioural Modelling: Structured procedures, initial and always, blocking and nonblocking statements, delay, control, generate statement, event control, conditional statements, multiway branching, loops, sequential and parallel block	
5		Design of Combinational and Sequential Circuits	8
	5.1	Design of Adders, Multiplexers, Demultiplexers, Encoders and Decoders using VERILOG.	
	5.2	Design of various Flip-Flops, Counters and Shift registers using VERILOG.	
	5.3	Design of ALU, IIR & FIR Filters using VERILOG.	
Total			30

Textbooks:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	Fundamentals of Digital Design	M. Senthil Sivakuma	S.Chand	4 th Edition 2023	1,2,
2	Verilog HDL	Samir Palnitkar	Pearson Education	2 nd Edition 2018	3,4,5

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Electronics and Computer Science

Reference Books:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	Digital Design Principal and Practises.	John F. Wakerly	PHI	4 th 2006	1,2,
2	Digital Design with RTL design VHDL and VERILOG	Frank Vahid	Wiley	2011	1,2
3	FPGA Prototyping by VERILOG Examples.	Pong.P.Chu	Wiley	3 rd	3,4,5
4	Advanced Digital Design with VERILOG HDL	Michael D. Ciletti.	Pearson	2 nd Edition 2018	3,4,5

Course Name: Digital System Design Lab

Course Code: PEEEC04P

NEP Vertical Basket: PC_PEC

Preamble:

Digital System design is a study of Programmable Logic Devices, Sequential Circuit Design, Introduction to VERILOG, Levels of Abstraction on VERILOG, and Design of Combinational and Sequential Circuits. This course aims to equip students with the necessary theoretical knowledge and practical skills required in the field of digital logic design and hardware description languages. Through a combination of theoretical lectures, practical demonstrations, and hands-on exercises, students will develop a comprehensive understanding of digital logic design principles and gain proficiency in using hardware description languages for circuit design and simulation.

Pre-requisites:

- Digital Electronics
- Electronic Devices and circuits.
- Basic of VLSI Design

Course Objectives:

- To explore the classification, concepts, and implementation of Programmable Logic Devices (PLDs)
- To learn about the building blocks of synchronous and asynchronous sequential circuits.
- To introduced to VERILOG, a hardware description language widely used in digital design.
- Design various Combinational and Sequential circuits using VERILOG.

Course Outcomes:

CO1: Design hardware that can be implemented on a variety of Programmable Logic Devices.
CO2: Design different sequential circuits using Finite state machine.
CO3: Understand basic entities of Verilog HDL.
CO4: Use various abstraction levels of Verilog HDL for a given application.
CO5: Design the combinational and sequential logic circuits using various constructs in Verilog

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Practical	25	-	25	50

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by

a panel constituted at institute level and published to the learners before the commencement of the semester.

Suggested List of Experiments:

Practical No.	Module No.	Suggested list of Experiments	Topics to be highlighted	CO Map
1	1,2,3,4,5	Study of simulation and synthesis using tools	Make student aware of different simulation and synthesis tools	1,2,3,4,5
2	1,2,3,4,5	Simulation and implementation of basic Logic Gates using VIVADO and SPRTAN7 FPGA.	Make modules of different logic gates which can be used in the hierarchical description of circuits.	1,2,3,4,5
3	1,2,3,4,5	Simulation and implementation of Half and Full Adder using VIVADO and SPRTAN7 FPGA.	Make modules of different adder which can be used in the hierarchical description of circuits.	1,2,3,4,5
4	1,2,3,4,5	Simulation and implementation of Multiplexers and Demultiplexers using VIVADO and SPRTAN7 FPGA.	Make modules of different mux and demux circuits which can be used in the hierarchical description of circuits.	1,2,3,4,5
5	1,2,3,4,5	Simulation and implementation of Encoder and Decoder using VIVADO and SPRTAN7 FPGA.	Make modules of different encoder and decoders which can be used in the hierarchical description of complex circuits	1,2,3,4,5
6	1,2,3,4,5	Simulation and implementation of Parallel Binary Adder using VIVADO and SPRTAN7 FPGA.	Make modules of different 4 -bit parallel adder which can be used in the hierarchical description of complex circuits. To determine delay in carry generation.	1,2,3,4,5
7	1,2,3,4,5	Simulation and implementation of Carry Look ahead Adder using VIVADO and SPRTAN7 FPGA.	Implementation of carry generation circuit and observe the speed improvement as compared to a ripple carry adder	1,2,3,4,5
8	1,2,3,4,5	Simulation and implementation of various flip-flops using VIVADO and SPRTAN7 FPGA.	Make modules of different various flip flops which can be used in the hierarchical description of complex circuits.	1,2,3,4,5
9	1,2,3,4,5	Simulation and implementation of Counters using VIVADO and SPRTAN7 FPGA.	Implement different counters and compare their performance	1,2,3,4,5
10	1,2,3,4,5	Simulation and implementation Shift Registers using VIVADO and SPRTAN7 FPGA.	Demonstrate PIPO, SISO SIPO and PISO operation	1,2,3,4,5
11	1,2,3,4,5	Simulation and implementation of basic ALU using VIVADO and SPRTAN7 FPGA.	Demonstrate concepts related to ALU design and implementation of various arithmetic and logical functions	1,2,3,4,5

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Textbooks:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	Fundamentals of Digital Design	M. Senthil Sivakuma	S.Chand	4 th Edition 2023	1,2,
2	Verilog HDL	Samir Palnitkar	Pearson Education	2 nd Edition 2018	3,4,5

Reference Books:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	Digital Design Principal and Practises.	John F. Wakerly	PHI	4 th 2006	1,2,
2	Digital Design with RTL design VHDL and VERILOG	Frank Vahid	Wiley	2011	1,2
3	FPGA Prototyping by VERILOG Examples.	Pong.P.Chu	Wiley	3 rd	3,4,5
4	Advanced Digital Design with VERILOG HDL	Michael D. Ciletti.	Pearson	2 nd Edition 2018	3,4,5

Course Name: Advanced VLSI Design and Technology

Course Code: PEEC08T

NEP Vertical Basket: PC_PEC

Preamble:

This course delineates a comprehensive course on Advanced VLSI Design, focusing on key topics essential for understanding and mastering contemporary semiconductor design methodologies and techniques. Through a structured approach, this course aims to equip students with the knowledge and skills necessary to navigate the complexities of VLSI design, including delay estimation, clocking methodologies, semiconductor manufacturing processes, semiconductor fabrication, and novel device technologies.

Pre-requisite:

- Digital Electronics
- Electronic Devices and Circuits
- Basics of VLSI Design

Course Objectives:

- To provide knowledge of fundamental building blocks of IC fabrication
- To design basic CMOS circuit layouts using Lambda design rules
- To be familiar with various VLSI technologies and novel devices

Course Outcomes:

After successful completion of the course students will be able to:

CO1: Demonstrate a clear understanding of delay estimation using concept of logical effort

CO2: Understand different VLSI Clocking and System Level Physical design issues.

CO3: Explain semiconductor manufacturing and crystal growth techniques.

CO4: Demonstrate a clear understanding of various MOS fabrication processes.

CO5: Study various VLSI technologies and novel devices.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	075

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

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Detailed Syllabus:

Module No.	Unit No.	Contents	Hrs.
1		Delay Estimation	07
	1.1	RC Delay Models, Elmore Delay Model, Linear Delay Model, interconnect scaling and crosstalk	
	1.2	Logical Effort and Transistor Sizing: Delay in a logic gate, Delay in a Multi-stage Logic Network, Choosing the best number of stages.	
2		VLSI Clocking and System Level Physical design	06
	2.1	Clock Generation, Stabilization and Distribution	
	2.2	Clocking Styles: Clocked Cascade, Timing Circle, Clock Skew and Clock Jitter	
	2.3	IO pads and Power Distribution: ESD protection, input circuits, output circuits, simultaneous switching noise, power distribution scheme.	
3		Semiconductor manufacturing requirements and Crystal growth	05
	3.1	Semiconductor Manufacturing: Semiconductor technology trend, clean rooms, Wafer cleaning and Gettering	
	3.2	Crystal growth techniques: Czochralski growth, Float Zone growth, Bridgman growth of GaAs, Wafer Preparation and specifications	
4		Semiconductor Fabrication Processes	06
	4.1	Oxidation, Deposition, Diffusion, Ion Implantation, Etching, Lithography, Metallization and contacts	
	4.2	CMOS Process Flow: N well, P-well and Twin tub, CMOS Latch Up Design rules: Layout of MOS based circuits (gates and combinational logic), Buried and Butting Contact	
5		Novel Devices	06
	5.1	Multi-gate Devices: Various multi-gate device configurations-double gate, triple gate (Fin-FET) and High K-Dielectrics	
	5.2	Nanowire: Concept, VLSI method of fabrication, Nanowire FETs	
	5.3	CNT FET: Introduction to Graphene and CNTFET structure	
		Total	30

Textbooks:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	Logical Effort: Designing Fast CMOS Circuits	Ivan Sutherland and Bob Sproull,	The Morgan Kaufmann Series in Computer Architecture and Design	4 th	1
2	CMOS VLSI Design: A Circuits and Systems Perspective	Neil H. E. Weste, David Harris and Ayan Banerjee,	Pearson Education	5 th	1,2
3	Silicon VLSI Technology	James D. Plummer, Michael D. Deal and Peter B. Griffin,	Pearson	5 th	3,4,5
4	VLSI Fabrication Principles],	Sorab K. Gandhi	Wiley	5 th	3,4,5

Third Year Scheme & Syllabus (R-2024) Bachelor of Technology (B.Tech.)
Electronics and Computer Science

Reference Books:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	Digital Integrated Circuits: A Design Perspective	Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic	Pearson Education	2 nd	2,3,4,5
2	Introduction to VLSI Circuits and Systems	John P. Uyemura	Wiley India Pvt. Ltd.	Revised 4 th Edition	3,4,5
3	CMOS Digital Integrated Circuits Analysis and Design	Sung-Mo Kang and Yusuf Leblebici,	Tata McGraw Hill	Revised 4 th Edition	1,2,3,4,5
4	Basics of CMOS Cell Design	Etienne Sicard and Sonia Delmas Bendhia	Tata McGraw Hill	4 th	1,2,3,4,5
5	Basic VLSI Design	Douglas A Pucknell, Kamran Eshraghian,	Prentice Hall of India Private Ltd.	3 rd	1,2,3,4,5
6	Analysis and Design of Digital Integrated Circuits	David Hodges, Horace Jackson, Resve Saleh.	McGraw-Hill, Inc.	3 rd	1,2,3,4,5
7	Advanced Semiconductor Memories: Architectures, Designs, and Applications	Ashok K. Sharma,	Wiley Publication	4 th	4
8	Magnetic Memory Technology: Spin-Transfer-Torque MRAM and Beyond	Denny D.Tang, Chi-Feng Pai,	Wiley online Library	2 nd	4
9	Resistive Switching: From Fundamentals of Nanoionic Redox Processes to Memristive Device Applications.	Daniele Ielmini, Rainer Waser,	Wiley online Library	3 rd	4

Course Name: Advanced VLSI Design and Technology Lab

Course Code: PEEC08P

NEP Vertical Basket: PC_PEC

Preamble:

This course delineates a comprehensive course on Advanced VLSI Design, focusing on key topics essential for understanding and mastering contemporary semiconductor design methodologies and techniques. Through a structured approach, this course aims to equip students with the knowledge and skills necessary to navigate the complexities of VLSI design, including delay estimation, clocking methodologies, semiconductor manufacturing processes, semiconductor fabrication, and novel device technologies.

Pre-requisite:

- Digital Electronics
- Electronic Devices and Circuits
- Basics of VLSI Design

Course Objectives:

- To provide knowledge of fundamental building blocks of IC fabrication
- To design basic CMOS circuit layouts using Lambda design rules
- To be familiar with various VLSI technologies and novel devices

Course Outcomes:

After successful completion of the course students will be able to:

CO1: Demonstrate a clear understanding of delay estimation using concept of logical effort

CO2: Understand different VLSI Clocking and System Level Physical design issues.

CO3: Explain semiconductor manufacturing and crystal growth techniques.

CO4: Demonstrate a clear understanding of various MOS fabrication processes.

CO5: Study various VLSI technologies and novel devices.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Practical	25	-	25	50

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised

assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Suggested list of Practical:

Practical No.	Module No.	Suggested list of Experiments	Topics to be highlighted	CO Map
1	1	Comparison of various delay models using CADENCE	Delay estimation using different delay models	CO1
2	1	Calculation of delay offered by FO4 inverter	Concept of estimating the least delay.	CO1
3	3	Simulation of oxidation process using ATCAD Lab of Nanohub.org.in	Oxidation process	CO3
4	3	Simulation of diffusion process using ATCAD Lab of Nanohub.org.in	Diffusion process	CO3
5	4	Design of CMOS inverter layout using Cadence tool	CMOS logic	CO4
6	4	Introduction to CADENCE for VLSI Design. Draw layout for given aspect ratio and implement CMOS inverter, CMOS NAND, NOR logic gates using CADENCE	CMOS logic	CO4
7	4	Implement half and full adder circuits and CADENCE (for layout) and verify functionality of the circuit	CMOS logic	CO4
8	5	Simulation of double gate FinFET using MugFET simulation using ATCAD lab of Nanohub. (nanohub.org.in)	FinFet working	CO5
9	1,2,3,4,5	Simulation of Complete Digital Design Flow in Cadence	Digital Design Flow using Cadence	CO1,2,3,4,5
10	1,2,3,4,5	Simulation of Complete Analog Design Flow in Cadence	Analog Design Flow using Cadence.	CO1,2,3,4,5

Course Name: Analog IC Design

Course Code: PEEC12T

NEP Vertical Basket: PC_PEC

Preamble:

This course focuses on the process of designing analog integrated circuits (ICs) using VLSI techniques. Analog circuits process continuously varying signals, in contrast to digital circuits that manipulate discrete binary values (0s and 1s). Analog VLSI Design involves creating circuits that perform functions such as amplification, filtering, signal conditioning, and analog-to-digital conversion. In Analog VLSI Design, engineers integrate multiple analog functions onto a single chip, often alongside digital components, to create complex systems-on-chip (SoCs) or mixed-signal integrated circuits. Analog VLSI Design poses unique challenges compared to digital design due to the inherent complexities of analog signals and the sensitivity of analog circuits to variations in manufacturing processes, temperature, and voltage. Engineers must carefully consider factors such as noise, distortion, power consumption, and layout parasitic to ensure that the designed circuits meet performance specifications under various operating conditions.

Pre-requisite:

- Digital Electronics
- Electronic Devices and Circuits
- Computer Organization and Architecture
- Basics of VLSI Design

Course Objectives:

- To Gain a deep understanding of fundamental analog circuit topologies, including amplifiers, filters, oscillators, and voltage reference.
- To learn the principles of VLSI design, including transistor-level design, layout techniques, and design verification.
- To explore techniques for optimizing analog circuit performance, such as maximizing bandwidth, achieving low noise, and minimizing power consumption.
- To apply theoretical concepts to real-world design projects, culminating in the design and simulation of complex analog integrated circuits.

Course Outcomes:

After successful completion of the course students will be able to:

CO1: Demonstrate the understanding of various building blocks and their use in design of analog circuits.

CO2: Analyze different single stage amplifiers.

CO3: Understand various types of differential amplifiers.

CO4: Design various OPAMP circuits

CO5: Discuss issues related to Analog Layout and design rules.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	075

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Module No.	Unit No.	Contents	Hrs.
1		Analog building blocks	06
	1.1	Need for CMOS analog and mixed signal designs, MOS Transistor as sampling switch, active resistances, current source and sinks, current mirror.	
	1.2	Voltage References: Band Gap References, General Considerations, Supply-independent biasing, PTAT & CTAT current generation, Temperature independent references and Constant Gm biasing	
2		Amplifier Fundamentals	06
	2.1	Single Stage Amplifiers: Common-source stage (with resistive load, diode connected load, current-source load, triode load, source degeneration), source follower, common-gate stage, cascode stage, folded cascode stage, Frequency response.	
	2.3	Noise: Statistical Characteristics of Noise, Types of Noise, Representation of Noise in circuits, Noise in Single stage amplifiers (CS, CD, CG stages), noise bandwidth, noise figure, noise temperature.	
3		Differential Amplifiers	06
	3.1	Differential Amplifiers: Single ended and differential operation, Basic differential pair, large signal and small signal behavior, Qualitative and Quantitative analysis of Common-mode and differential Mode, Frequency response	
	3.2	Differential Pair with MOS Loads, Gilbert Cell, Noise in differential pairs	
4		MOS Operational Amplifiers	08
	4.1	Op-amp Design: General Considerations, performance parameters, One-stage op-amps, Two-stage op-amps, Gain Bandwidth (GBW), Gain Boosting, Common-mode feedback, Input range limitations (ICMR), Slew Rate, Power supply rejection, Noise in op-amps.	
	4.2	Stability and Frequency Compensation: General Considerations, Multipole systems, Phase margin, Frequency compensation, compensation of two stage op- amps.	
	4.3	Design of single ended and double ended two stage Op-amps	
5		Analog Layouts	04
	5.1	General Layout considerations, Design Rules & antenna Effect	
	5.2	Analog Layout techniques: Multi-finger transistors, symmetry, shallow trench Isolation Issues, well proximity effects, reference distribution, passive devices, interconnect, pads and ESD protection.	
Total			30

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Electronics and Computer Science

Textbooks:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	Design of Analog CMOS Integrated Circuits	Behzad Razavi	Tata McGraw Hill	2 nd	1,2,3,4,5
2	CMOS Circuit Design, Layout, and Simulation	R. Jacob Baker, Harry W. Li, David E. Boyce	Wiley	2 nd	1,2,3,4,5
3	CMOS Analog Circuit Design	P. E. Allen and D. R. Holberg	Oxford University Press	3 rd	1,2,3,4,5
4	Analysis and design of Analog Integrated Circuits	Gray, Meyer, Lewis, Hurst	Wiley	5 th	1,2,3,4,5

Reference Books:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	CMOS Circuit Design, Layout and Simulation	Baker Li Boyce	Wiley	3 rd	1,2,3,4,5
2	Digital Integrated Circuits: A Design Perspective	Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic	Pearson Education	2 nd	2,3,4,5
3	Introduction to VLSI Circuits and Systems	John P. Uyemura	Wiley India Pvt. Ltd.	Revised 4 th Edition	3,4,5
4	CMOS Digital Integrated Circuits Analysis and Design	Sung-Mo Kang and Yusuf Leblebici,	Tata McGraw Hill	Revised 4 th Edition	1,2,3,4,5
5	Basics of CMOS Cell Design	Etienne Sicard and Sonia Delmas Bendhia	Tata McGraw Hill	4 th	1,2,3,4,5
6	CMOS VLSI Design: A Circuits and Systems Perspective	Neil H. E. Weste, David Harris and Ayan Banerjee,	Pearson Education	5 th	1,2,3,4,5
7	Analysis and Design of Digital Integrated Circuits	David Hodges, Horace Jackson, Resve Saleh.	McGraw-Hill, Inc.	3 rd	1,2,3,4,5
8	Basic VLSI Design	Douglas A Pucknell, Kamran Eshraghian,	Prentice Hall of India Private Ltd.	3 rd	1,2,3,4,5

Course Name: Analog IC Design Lab

Course Code: PEEC12P

NEP Vertical Basket: PC_PEC

Preamble:

This course focuses on the process of designing analog integrated circuits (ICs) using VLSI techniques. Analog circuits process continuously varying signals, in contrast to digital circuits that manipulate discrete binary values (0s and 1s). Analog VLSI Design involves creating circuits that perform functions such as amplification, filtering, signal conditioning, and analog-to-digital conversion. In Analog VLSI Design, engineers integrate multiple analog functions onto a single chip, often alongside digital components, to create complex systems-on-chip (SoCs) or mixed-signal integrated circuits. Analog VLSI Design poses unique challenges compared to digital design due to the inherent complexities of analog signals and the sensitivity of analog circuits to variations in manufacturing processes, temperature, and voltage. Engineers must carefully consider factors such as noise, distortion, power consumption, and layout parasitic to ensure that the designed circuits meet performance specifications under various operating conditions.

Pre-requisite:

- Digital Electronics
- Electronic Devices and Circuits
- Computer Organization and Architecture
- Basics of VLSI Design

Course Objectives:

- To Gain a deep understanding of fundamental analog circuit topologies, including amplifiers, filters, oscillators, and voltage reference.
- To learn the principles of VLSI design, including transistor-level design, layout techniques, and design verification.
- To explore techniques for optimizing analog circuit performance, such as maximizing bandwidth, achieving low noise, and minimizing power consumption.
- To apply theoretical concepts to real-world design projects, culminating in the design and simulation of complex analog integrated circuits.

Course Outcomes:

After successful completion of the course students will be able to:

CO1: Demonstrate the understanding of various building blocks and their use in design of analog circuits.

CO2: Analyze different single stage amplifiers.

CO3: Understand various types of differential amplifiers.

CO4: Design various OPAMP circuits

CO5: Discuss issues related to Analog Layout and design rules.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Practical	25	-	25	50

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Suggested list of Practical:

Practical No.	Module No.	Suggested list of Experiments	Topics to be highlighted	CO Map
1	1	Analysis of MOSFETs for analog performance	Effect of Body Bias and Channel Length Modulation	CO1
2	1	Design and simulate various types of current mirror circuits	Design of Current Mirrors and techniques to mitigate the effect of channel length modulation	CO1
3	2	Design and simulate various common source amplifier circuits	Compare various types of common source amplifier	CO2
4	2	Design and simulate various types of Common Drain amplifiers	Compare various types of common drain amplifier	CO2
5	2	Design and simulate various types of Common Gate amplifiers	Compare various types of common gate amplifier	CO2
6	3	Design and simulate differential amplifier	Compare various types of differential amplifier	CO3
7	4	Design and simulate operational transconductance amplifier	Compare various topologies of OPAMPS	CO4
8	5	Generate layout for the simple and cascode current mirror	Layout Design Issues while designing cascode amplifier	CO5
9	5	Generate layout for common source amplifier	Layout Design Issues while designing common source amplifier	CO5
10	5	Generate layout for the differential amplifier	Layout Design Issues while designing differential amplifier	CO5
11	1,2,3,4,5	Simulation of Complete Digital Design Flow in Cadence	Digital Design Flow using Cadence	CO1,2,3,4,5,6
12	1,2,3,4,5	Simulation of Complete Analog Design Flow in Cadence	Analog Design Flow using Cadence.	CO1,2,3,4,5,6

Third Year Scheme & Syllabus (R-2024) Bachelor of Technology (B.Tech.)
Electronics and Computer Science

Textbooks:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
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2	CMOS Circuit Design, Layout, and Simulation	R. Jacob Baker, Harry W. Li, David E. Boyce	Wiley	2 nd	1,2,3,4,5
3	CMOS Analog Circuit Design	P. E. Allen and D. R. Holberg	Oxford University Press	3 rd	1,2,3,4,5
4	Analysis and design of Analog Integrated Circuits	Gray, Meyer, Lewis, Hurst	Wiley	5 th	1,2,3,4,5

Reference Books:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
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2	Digital Integrated Circuits: A Design Perspective	Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic	Pearson Education	2 nd	2,3,4,5
3	Introduction to VLSI Circuits and Systems	John P. Uyemura	Wiley India Pvt. Ltd.	Revised 4 th Edition	3,4,5
4	CMOS Digital Integrated Circuits Analysis and Design	Sung-Mo Kang and Yusuf Leblebici,	Tata McGraw Hill	Revised 4 th Edition	1,2,3,4,5
5	CMOS VLSI Design: A Circuits and Systems Perspective	Neil H. E. Weste, David Harris and Ayan Banerjee,	Pearson Education	5 th	1,2,3,4,5
6	Analysis and Design of Digital Integrated Circuits	David Hodges, Horace Jackson, Resve Saleh.	McGraw-Hill, Inc.	3 rd	1,2,3,4,5
8	Basic VLSI Design	Douglas A Pucknell, Kamran Eshraghian,	Prentice Hall of India Private Ltd.	3 rd	1,2,3,4,5

Detailed Syllabus of Multidisciplinary Minor Courses

Course Name: Strategic Marketing and Business Planning

Course Code: MDMBD03

NEP Vertical_Basket: MDC_MDM

Preamble:

The objective of this course is to advance the student's knowledge in planning and managing a business in the tech sector with an emphasis on marketing strategy, branding, and market expansion.

Pre-requisites:

Introduction to Business Development and Marketing Principles, Financial Basics for Engineers and Technopreneurs

Course Objectives:

- Create effective marketing and branding strategies for engineering products.
- Explore B2B and B2C models.
- Learn to write a business plan.
- Evaluate market entry and scale-up strategies.

Course Outcomes:

Students will be able to:

CO1: Draft a business plan with marketing, operations and financial sections.

CO2: Create a brand positioning strategy for a tech product.

CO3: Compare different go-to-market models and digital strategies.

CO4: Design a simple customer acquisition funnel

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	20	30	50	100

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Strategic Marketing	Market analysis techniques, segmentation and targeting, positioning strategy, BCG Matrix, SWOT analysis.	9
2	Branding and Identity	Elements of branding, creating brand equity, storytelling, brand positioning strategy for tech startups.	7
3	Market Entry Strategy	Domestic vs international markets, pricing models, product launch strategy, sales forecasting.	7
4	Business Planning	Components of a business plan including executive summary, marketing plan, operations, HR, and financial plan.	10
5	Customer Acquisition	Customer acquisition cost (CAC), sales funnels, CRM basics, online and offline channel strategy.	6
6	Technology Markets	Market behavior and innovation diffusion in electronics and telecommunication sectors. Case studies.	6
Total			45

PO Mapping by Module:

- Module 1: PO3, PO5
- Module 2: PO6, PO10
- Module 3: PO7, PO11
- Module 4: PO11, PO12
- Module 5: PO3, PO9
- Module 6: PO2, PO6

Textbooks:

2. Marketing for Entrepreneurs- Frederick Crane, Sage Publications

Reference Books:

2. How to Build a Startup - Udacity Free Course

Course Name: Strategic Marketing and Business Planning Tutorial

Course Code: MDMBD03

NEP Vertical_Basket: MDC_MDM

Preamble:

The objective of this course is to advance the student's knowledge in planning and managing a business in the tech sector with an emphasis on marketing strategy, branding, and market expansion.

Pre-requisites:

Introduction to Business Development and Marketing Principles, Financial Basics for Engineers and Technopreneurs

Course Objectives:

- Create effective marketing and branding strategies for engineering products.
- Explore B2B and B2C models.
- Learn to write a business plan.
- Evaluate market entry and scale-up strategies.

Course Outcomes:

Student will be able to:

CO1: Draft a business plan with marketing, operations and financial sections.

CO2: Create a brand positioning strategy for a tech product.

CO3: Compare different go-to-market models and digital strategies.

CO4: Design a simple customer acquisition funnel

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Tutorial	Theory	Tutorial
-	1	-	1

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Tutorial	25	-	-	25

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Suggested list of Tutorial:

1. Strategic analysis of a local brand (2 hrs)
2. Develop a mock business plan (2 hrs) 3
3. Brand storytelling and pitch creation (2 hrs)
4. Marketing channel mapping (2 hrs)
5. Business simulation case review (2 hrs)
6. Business pitch drill (3 hrs)
7. Analysis of brand elements of any start up tech brand of choice/ Plan for international market entry of a tech brand (2 hrs)

Textbooks:

2. Marketing for Entrepreneurs- Frederick Crane, Sage Publications

Reference Books:

2. How to Build a Startup - Udacity Free Course

Course Title: Innovation Management and Scaling Startups

Course Code: MDMIE03

NEP Vertical_Basket: MDC_MDM

Preamble:

This course is designed to help students understand how startups and innovation-driven organizations move beyond the early idea and planning stage into product-market fit, growth, scale, and long-term sustainability. Building on the concepts introduced in Foundations of Innovation and Entrepreneurship and Startup Planning and Development, the course focuses on managing innovation, developing scalable products, building growth strategies, creating partnerships, using emerging technologies responsibly, and preparing ventures for expansion.

The course combines global innovation frameworks with practical startup scaling methods used by founders, product teams, investors, and innovation leaders. Students will explore how organizations manage innovation portfolios, use agile and AI-enabled product development practices, measure growth through startup metrics, scale operations and teams, build strategic partnerships, and address responsible innovation, sustainability, data privacy, and AI governance.

The teaching approach is case-based and application-oriented, with emphasis on real-world examples, technology-led ventures, group activities, startup growth analysis, and scale-up strategy development.

Pre-requisites: NIL

Course Objectives:

- To introduce students to innovation management and startup scale-up strategies.
- To develop understanding of product-market fit, product development, and growth metrics.
- To expose students to AI-enabled innovation, digital business models, partnerships, and global scaling.
- To build awareness of responsible innovation, sustainability, data privacy, and governance in scaling ventures.
- To enable students to prepare a practical scale-up strategy for a technology-driven startup.

Course Outcomes:

Students will be able to:

CO1: Formulate innovation strategies for technology-driven ventures and growing organizations.

CO2: Apply product development, agile, and AI-assisted innovation methods for scalable solutions.

CO3: Analyse product-market fit, growth metrics, business model scalability, and scale-up strategies.

CO4: Evaluate partnerships, funding, responsible AI, sustainability, and governance issues in scaling startups.

Course Scheme:

Course Code	Contact Hours		Credits Assigned	
	Theory	Tutorial	Theory	Tutorial
MDMIE03	3	1	3	1

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	45	30	50	125

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Innovation Strategy and Management	Meaning and types of innovation. Incremental, disruptive, architectural, and business model innovation. Innovation lifecycle and innovation portfolio. Open innovation, co-creation, and ecosystem-based innovation. Building a culture of innovation in growing organizations. Managing innovation in early-stage, growth-stage, and established organizations.	8
2	Product-Market Fit and AI-Enabled Product Development	Product-market fit and customer feedback loops. Product roadmap and feature prioritization. Agile and Scrum fundamentals. Rapid prototyping and testing. No-code and low-code tools for prototyping. AI-assisted ideation, design, user research, content creation, code generation, and product workflows. Build versus buy decisions for digital and AI-enabled products.	10
3	Growth Strategy and Scaling Metrics	Startup growth models and growth loops. North Star Metric, KPIs, and OKRs. Customer acquisition, activation, retention, referral, and revenue. Growth experiments and data-driven decision-making. AI-assisted analytics, personalization, and marketing automation. Scaling operations, customer support, teams, and organizational processes. Common scale-up challenges and failure patterns.	10
4	Funding, Partnerships and Global Scale-Up	Growth-stage funding and investor readiness. Basics of valuation, cap table awareness, and funding rounds. Strategic partnerships, alliances, platform thinking, and distribution partnerships. Role of incubators, accelerators, corporates, government bodies, and startup ecosystems. Internationalization of startups, market entry models, and cross-border scaling challenges. Mergers, acquisitions, and acqui-hire concepts at an introductory level.	8
5	Responsible Innovation and Sustainable Entrepreneurship	Responsible innovation and ethical scaling. Responsible AI, data privacy, cybersecurity awareness, transparency, fairness, and accountability in digital products. ESG basics and triple bottom line. Social entrepreneurship and impact-driven business models.	9

		Impact measurement. Founder resilience, team well-being, and sustainable work culture during scale-up. Long-term resilience and governance in scaling ventures.	
Total			45

Tutorials:

- Case study analysis of Indian and global scaling startups.
- Innovation audit of an existing product, startup, or organisation.
- Product-market fit analysis using customer personas and feedback loops.
- Prototype testing workshop using no-code, low-code, or AI-assisted tools.
- Growth metrics worksheet using KPIs, OKRs, funnel metrics, retention, and revenue logic.
- AI-assisted startup scaling exercise for market research, product ideas, customer communication, and growth planning.
- Investor and partnership role-play discussion.
- Responsible AI, privacy, sustainability, and ethical scaling discussion.
- Group activity: preparing a scale-up strategy for a selected startup idea.

Textbooks:

1. Clayton M. Christensen, The Innovator's Dilemma, Harvard Business Review Press.
2. Peter F. Drucker, Innovation and Entrepreneurship, HarperBusiness.
3. Sean Ellis and Morgan Brown, Hacking Growth, Currency.
4. Geoffrey A. Moore, Crossing the Chasm, HarperBusiness.
5. Eric Ries, The Startup Way, Currency

Reference Reading:

2. Reid Hoffman and Chris Yeh, Blitzscaling, Currency.
3. Alexander Osterwalder and Yves Pigneur, Business Model Generation, Wiley.
4. Steve Blank and Bob Dorf, The Startup Owner's Manual, K&S Ranch.
5. OECD/Eurostat, Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation. <https://doi.org/10.1787/9789264304604-en>
6. NIST, Artificial Intelligence Risk Management Framework (AI RMF 1.0). <https://www.nist.gov/itl/ai-risk-management-framework>
7. World Economic Forum, Future of Jobs Report 2025. <https://www.weforum.org/publications/the-future-of-jobs-report-2025/>
8. Selected case studies and reports from [Y Combinator Startup Library](#), Harvard Business Review, MIT Technology Review, NASSCOM, and Startup India.

Course Name: Machine Learning Applications in Bioinformatics

Course Code: MDMBI03

Vertical/ Sub-Vertical: MDM

K-S-A Mapping: Knowledge and Skills

Pre-requisite required: MDMBI01 (Introduction to Bioinformatics), PCIT15T (Machine Learning)

Pre-requisite for: NIL

Recommended Semester: 7

Course Scheme:

Course Code	Contact Hours		Credits Assigned	
	Theory	Practical	Theory	Practical
MDMBI03	3+1*	-	4	-

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	45	30	50	125

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Preamble:

This course introduces the integration of Machine Learning techniques with Bioinformatics for analyzing complex biological data. It covers fundamental concepts of bioinformatics, biological datasets, and essential machine learning methods including supervised, unsupervised, and deep learning approaches. The course emphasizes data preprocessing, pattern recognition, and predictive modeling in genomics, proteomics, and other omics data. It also highlights real-world applications in healthcare such as disease prediction, drug discovery, and precision medicine. The subject aims to equip students with analytical and computational skills required for modern biological and biomedical research.

Course Objectives:

- To introduce the fundamental concepts of bioinformatics and machine learning for biological data analysis.
- To enable students to apply data preprocessing, feature selection, and representation techniques on biological datasets.
- To develop the ability to apply supervised and unsupervised learning algorithms for solving bioinformatics problems.
- To provide understanding of deep learning methods and their applications in genomics, proteomics, and healthcare analytics.

Course Outcomes:

Learner will be able to:

Course Outcomes	Course Outcome Statement	Bloom's Level
CO1	Explain the fundamental concepts of bioinformatics and machine learning techniques.	Remember
CO2	Describe biological data preprocessing, feature selection, and data representation methods.	Understand
CO3	Apply supervised learning algorithms for classification and prediction in bioinformatics.	Apply
CO4	Apply clustering and pattern recognition techniques on biological datasets.	Apply
CO5	Analyze deep learning models used in sequence and structure analysis.	Analyze
CO6	Analyze machine learning applications in healthcare and bioinformatics domains.	Analyze

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours	CO's Mapped
1	Introduction to Bioinformatics and Machine Learning	Overview of bioinformatics, Biological datasets, Challenges in biological data analysis, Introduction to Artificial Intelligence and Machine Learning, Applications of ML in bioinformatics and healthcare	6	CO1
2	Data Preprocessing and Biological Data Representation	Biological data representation, Data cleaning and preprocessing, Handling missing biological data, Feature engineering and feature selection, Data normalization and scaling, Data visualization techniques, Applications such as disease prediction based on gene expression data.	7	CO2
3	Supervised Learning Techniques in Bioinformatics	Introduction to supervised learning, Regression techniques, Classification algorithms - K-Nearest Neighbours (KNN), Decision Trees, Random Forest, Support Vector Machines (SVM), Model evaluation metrics, Cross-validation and model optimization. Application such as Protein function prediction	9	CO3
4	Unsupervised Learning and Pattern Recognition	Introduction to unsupervised learning, Clustering methods - K-Means clustering, Hierarchical clustering, DBSCAN, Dimensionality reduction, Pattern recognition in omics data, Association analysis in biological datasets, Application like Protein-Protein Interactions etc.	7	CO4
5	Deep Learning Applications in Bioinformatics	Introduction to deep learning, Artificial Neural Networks (ANN), Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), Transformers and attention mechanisms, Protein folding and structure prediction. Application like Biomedical image analysis.	8	CO5

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6	Advanced Machine Learning Applications in Bioinformatics	Ensemble learning techniques, Explainable AI (XAI) in healthcare, Machine learning in genomics and precision medicine, Drug discovery and virtual screening, Biomedical signal and image analysis, AI-driven disease diagnosis, Ethical issues and bias in biomedical AI, Emerging trends in AI for bioinformatics	8	CO6
Total			45	

Textbooks:

4. P. Baldi and S. Brunak, *Bioinformatics: The Machine Learning Approach*, 2nd ed. Cambridge, MA, USA: MIT Press, 2001.
5. Goodfellow, Y. Bengio, and A. Courville, *Deep Learning*. Cambridge, MA, USA: MIT Press, 2016. Hardcover edition available.
6. M. Lesk, *Introduction to Bioinformatics*, 5th ed. Oxford, UK: Oxford University Press, 2019.

Reference Books:

4. C. M. Bishop, *Pattern Recognition and Machine Learning*. New York, NY, USA: Springer, 2006. Hardcover edition widely available.
5. T. Hastie, R. Tibshirani, and J. Friedman, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*, 2nd ed. New York, NY, USA: Springer, 2009. Hardcover edition available.
6. S. J. D. Prince, *Understanding Deep Learning*. Cambridge, MA, USA: MIT Press, 2023. Hardcover edition available.

Online Reference Material:

5. Coursera – Bioinformatics Specialization (UC San Diego) - <https://www.coursera.org/specializations/bioinformatics>
6. Scikit-learn Official Documentation - https://scikit-learn.org/stable/user_guide.html
7. DeepLearning.AI Courses - <https://www.deeplearning.ai/courses/>
8. EMBL-EBI Training Portal - https://www.ebi.ac.uk/training/?utm_source=chatgpt.com

Course Name: Intelligent Mobile Robotics

Course Code: MDMRB03

Category: Multidisciplinary Minor (MDM)

Preamble:

This course introduces the fundamentals of mobile robotics with an emphasis on navigation and path planning. Students learn how mobile robots perceive their environment, localize themselves, and plan safe and efficient paths using classical and optimization-based algorithms such as Bug methods, A*, Potential Fields, and Gradient Descent.

Course Objectives:

- To understand the kinematics, sensing, and perception principles governing mobile robot motion and environment interaction.
- To apply localization, mapping, and classical path planning algorithms for autonomous navigation.
- To design and evaluate optimization-based and intelligent path planning strategies for smooth and collision-free robot motion.

Pre-requisites:

Fundamentals of Robotics and Control (BMMDM1T)

Course Outcome: The students will be able to:

- CO1: Explain the fundamentals of mobile robots, locomotion mechanisms, and kinematic principles including wheel constraints, manoeuvrability, and motion control of mobile robotic systems. (Modules 1 & 2)
- CO2: Describe the principles of robot perception, sensor systems, uncertainty representation, and feature extraction techniques used in mobile robots. (Module 3)
- CO3: Apply localization and mapping techniques including probabilistic localization, belief representation, and map representation for determining robot position in an environment. (Module 4)
- CO4: Analyze localization-based navigation methods and autonomous map-building techniques for mobile robot navigation. (Modules 4 & 5)
- CO5: Design path planning and obstacle avoidance strategies for autonomous mobile robots using planning and reacting approaches. (Module 5)
- CO6: Evaluate navigation architectures, decomposition techniques, and modern autonomous navigation systems used in intelligent mobile robots. (Module 6)

Course Scheme:

Course Code	Contact Hours		Credits Assigned	
	Theory	Practical	Theory	Practical
MDMRB03	3	2	3	1

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory+ Tutorial	45	30	50	125

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose a revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Module Contents	No. of Hours
01	Introduction and Locomotion	Introduction to mobile robots; overview of mobile robotics; key issues in locomotion; legged mobile robots; leg configurations and stability; examples of legged locomotion; wheeled mobile robots; wheeled locomotion design space; case studies of wheeled mobile robots.	07
02	Mobile Robot Kinematics	Kinematic models and constraints; representation of robot position; forward kinematic models; wheel kinematic constraints; robot kinematic constraints; examples of robot kinematic models; mobile robot manoeuvrability; degree of mobility and steerability; robot workspace; holonomic robots; path and trajectory considerations; motion control — open loop and feedback control.	08
03	Perception	Sensors for mobile robots; sensor classification and performance; wheel and motor sensors; heading sensors; ground-based beacons; active ranging; motion and speed sensors; vision-based sensors; representing uncertainty; statistical representation; error propagation; feature extraction using range and visual data.	07
04	Mobile Robot Localization	Introduction to localization; challenges of localization — noise and aliasing; sensor noise; sensor aliasing; effector noise; odometric error models; localization-based navigation; belief representation; map representation; probabilistic map-based localization; Markov localization; Kalman filter localization; landmark-based navigation; positioning beacon systems; route-based localization.	08
05	Autonomous Mapping and Navigation	Autonomous map building; stochastic map technique; other mapping techniques; introduction to planning and navigation; competences for navigation — planning and reacting; path planning; obstacle avoidance techniques.	08

Module No.	Module Name	Module Contents	No. of Hours
06	Navigation Architectures	Navigation architectures; modularity for code reuse and sharing; control localization; techniques for decomposition; case studies of tiered robot architectures; introduction to modern navigation systems and autonomous mobile robots.	08
Total			45

Suggested List of Value-Added Home Assignments

7. Design and simulate a wheeled mobile robot capable of autonomous navigation and obstacle avoidance in an indoor environment using ultrasonic or LiDAR sensors.
8. Develop a vision-based mobile robot system for object detection and sorting using a camera and a basic machine learning or image processing technique.
9. Implement a mobile robot simulation that performs path planning and navigation for automated material handling in a warehouse environment.
10. Design a voice-controlled mobile robot using speech recognition tools to execute commands such as movement, navigation, or environmental monitoring.
11. Build a prototype or simulation of a surveillance mobile robot capable of detecting motion or intrusions and generating alerts through a monitoring interface.
12. Simulate a multi-robot system for cooperative exploration and mapping of an unknown environment using onboard sensors and communication between robots.

Problem-Based Experiments (PBL List)

21. Study different types of mobile robots and compare legged and wheeled locomotion using suitable case studies or simulations.
22. Analyze the stability and maneuverability of legged mobile robots for different leg configurations.
23. Simulate wheeled mobile robots and study the effect of wheel arrangements on robot motion.
24. Develop a kinematic model for a differential drive robot and simulate its movement for different velocity inputs.
25. Analyze wheel kinematic constraints and robot kinematic constraints for mobile robotic systems.
26. Study the maneuverability of holonomic and non-holonomic robots using simulation tools.
27. Implement open-loop and feedback motion control for trajectory tracking of a mobile robot.
28. Interface and simulate wheel encoders, ultrasonic sensors, LiDAR, and vision sensors for mobile robots.
29. Analyze the performance characteristics of different sensors used in mobile robots.
30. Represent uncertainty in sensor measurements and study error propagation using simulated sensor data.
31. Perform feature extraction using range data or vision-based sensor inputs for object identification.
32. Implement dead reckoning localization using odometry data and analyze localization errors.
33. Apply Kalman filter localization for improving robot pose estimation using sensor fusion.
34. Implement particle filter or Markov localization techniques in a known environment.
35. Develop and compare different map representation methods for mobile robot navigation.
36. Simulate landmark-based and beacon-based localization methods for autonomous robots.
37. Implement autonomous map building using basic SLAM or stochastic mapping techniques.
38. Develop path planning algorithms for mobile robot navigation in obstacle-filled environments.

39. Implement obstacle avoidance techniques for autonomous mobile robots using sensor inputs.
40. Study modular navigation architectures and simulate autonomous navigation of a mobile robot in ROS or a virtual environment.

Recommended Online Courses:

5. Computer Vision Specialization (by University of Buffalo)
<https://www.coursera.org/specializations/computer-vision>
6. NPTEL: Wheeled Mobile Robots, IITM IIT Palakkad. nptel.ac.in/courses/112106298
7. Computer Vision, <https://www.udacity.com/course/computer-vision-nanodegree--nd891>
8. OpenCVBootcamp, https://opencv.org/university/free-opencv-course/?utm_source=google&utm_medium=cpc&utm_campaign=WW_tut_OBC&utm_term=best%20opencv%20tutorial&gad_source=1&gad_campaignid=21004628838&gbraid=0AAAAACbv-xhUM70mKirK31LiktTRipo8G&gclid=Cj0KCQjw9O_BBhCUARIsAHQMjS7VA3JEdz8KONvGanFNC7KAqSt2HModiDtp5hB_PJKX_oKTK80pNxQaAlcVEALw_wcB

Reference Books / Articles

7. Siegwart, Roland, Illah R. Nourbakhsh, and Davide Scaramuzza, Introduction to Autonomous Mobile Robots, MIT Press, 2nd Edition, 2011.
8. Choset, Howie, Kevin M. Lynch, Seth Hutchinson et al., Principles of Robot Motion: Theory, Algorithms, and Implementations, MIT Press, 1st Edition, 2005.
9. Russell, Stuart J., and Peter Norvig, Artificial Intelligence: A Modern Approach, Pearson Education, 3rd Edition, 2010.
10. Craig, John J., Introduction to Robotics: Mechanics and Control, Pearson Education, 3rd Edition, 2009.
11. Wooldridge, Michael, An Introduction to MultiAgent Systems, Wiley, 2nd Edition, 2009.
12. Grover, Vikram, Mastering UiPath Studio: A Beginner's Guide to Robotic Process Automation, BPB Publications, 1st Edition, 2021.

Course Name: Professional Competency Development 3

Course Code: MDM03

Vertical/ Sub-Vertical: Open Elective Courses

K-S-A Mapping: Skill

Pre-requisite required: OEC15 (Professional Competency Development 2)

Pre-requisite for: OEC17 (Professional Competency Development 4)

Course Level:

Recommended Semester: 6

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2		1

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	50	-	-	-

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Revisiting Complexity Concepts and Optimization	Growth Functions, Asymptotic Notations, Recurrence Relations Basic Algorithm Designs for Problem Solving – Brute Force, Greedy Algorithms, Divide and Conquer	4
2	Algorithm Designs	Advanced Algorithm Designs – Dynamic Programming, Backtracking and Branch and Bound	4
3	Competitive Coding 1	Competitive Codes on Binary Search, Linked List, Tree with DFS, BFS and BST, Priority Queue/Heap, and DEQueue,	5
4	Competitive Coding 2	Competitive Codes on Graph with DFS/BFS, Topological Sort, Minimum Spanning Tree, Shortest Path Algorithms	5
5	Aptitude Test Preparation 1	Numerical reasoning, Logical Interpretation with emphasis on accuracy and time-bound problem solving. Logical pattern identification, sequential reasoning, relational analysis, and visual interpretation.	6

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		Structured thinking through case-based scenarios, prioritization tasks, and decision-based problem evaluation.	
6	Aptitude Test Preparation 2	Sentence structure, grammatical accuracy, contextual word usage, and comprehension of written passages. Logical interpretation of verbal information, clarity in expression, and professional communication skills for interviews and workplace interactions.	6
Total			30

Tools/ Technologies/ Programming Languages learnt:

- Programming Languages: C, Java.
- Integrated Development Environments (IDEs): Visual Studio Code, Eclipse.
- Code Practice Platforms: LeetCode, HackerRank, CodeSignal.
- Version Control Systems: Git and GitHub.
- Online Learning Platforms with Interactive Coding Environments: Jupyter Notebook, Repl.it.

Textbooks:

5. E. Balagurusamy, "Programming in ANSI C", 8th Edition, McGraw Hill Education, 2019
6. Yashavant Kanetkar, "Let Us C", 17th Edition, BPB Publications, 2023.
7. Herbert Schildt, "JAVA: The Complete Reference", Oracle Press.
8. R.S. Aggarwal, "Quantitative Aptitude for Competitive Examinations", Revised Edition, S. Chand Publishing, 2018.
9. Norman Lewis, "Word Power Made Easy", Revised Edition, Goyal Publishers, 2014.

Reference Books:

4. Brian W. Kernighan, Dennis M. Ritchie, "The C Programming Language", 2nd Edition, Prentice Hall, 1988.
5. Dietal and Dietal, "Java: How to program", Prentice Hall.
6. Stevan Jolzner, "JAVA Programming- Black Book", Dreamtech Press.
7. Arun Sharma, "How to Prepare for Quantitative Aptitude for the CAT", 9th Edition, McGraw Hill Education, 2018.
8. S.P. Bakshi, "Objective General English", 4th Edition, Arihant Publications, 2017

Related/ Equivalent MOOC and Associated Certification:

1. Introduction to C Programming
Platform: NPTEL (National Programme on Technology Enhanced Learning)
Instructor: Prof. Anupam Basu, IIT Kharagpur
Link: <https://nptel.ac.in/courses/106105085>
2. Programming in C
Platform: SWAYAM-NPTEL
Instructor: Prof. Shriram K. Vasudevan, IIT Madras
Link: <https://nptel.ac.in/courses/106105171>

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3. Programming in Java
Platform: SWAYAM-NPTEL
Instructor: Prof. Debasis Samanta, IIT Kharagpur
Link: nptel.ac.in/courses/106105191
4. NPTEL, "Developing Soft Skills and Personality", SWAYAM–NPTEL, IIT Kanpur, with NPTEL Certification.
5. Coursera, "*Improving Communication Skills*", University of Pennsylvania, with Coursera Certification.
6. LinkedIn Learning, "*Learning Personal Effectiveness*", LinkedIn Learning Platform, with LinkedIn Certification.