AC –
Item No. –

As Per NEP 2020

University of Mumbai

Syllabus for Major **Vertical – 1, 4 & 5**		
Name of the Programme – B.E. (Electronics and Computer Engineering)		
Faulty of Engineering		
Board of Studies in Electronics and Computer Engineering		
U.G. Third Year Programme	**Exit Degree**	**B.Sc. Tech Engineering- Electronics and Computer Engineering**
Semester		**V & VI**
From the Academic Year		**2026-27**

University of Mumbai

(As per NEP 2020)

Sr. No.	Heading	Particulars
1	**Title of program** **O:_____**	**B.E. (Electronics and Computer Engineering)**
2	**Exit Degree**	**B.Sc. Tech Engineering- Electronics and Computer Engineering**
3	**Scheme of Examination** **R: _____**	NEP 40% Internal 60% External, Semester End Examination Individual Passing in Internal and External Examination
4	**Standards of Passing** **R: _____**	**40%**
5	**Credit Structure** **R: _____**	**Attached herewith**
6	**Semesters**	**Sem. V & VI**
7	**Program Academic Level**	**5.5**
8	**Pattern**	**Semester**
9	**Status**	**New**
10	**To be implemented from Academic Year**	**2026-27**

Sd/-	**Sd/-**	**Sd/-**
Dr. R.N.Awale	**Dr. Deven Shah**	**Prof. Shivram S. Garje**
BoS-Chairman-Electronics and Computer Science	**Associate Dean**	**Dean**
Faculty of Technology	**Faculty of Science & Technology**	**Faculty of Science & Technology**

Preamble

To meet the challenge of ensuring excellence and NEP 2020 policy in engineering education, the issue of quality needs to be addressed, debated, and taken forward systematically. Accreditation is the principal means of quality assurance in higher education. The major emphasis of the accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering) of the University of Mumbai has taken the lead in incorporating the philosophy of NEP 2020 education in the process of curriculum development.

The third-year engineering course consists of a core and elective training program to impart scientific and logical thinking training to learners in general, with a choice of course selection from the program core course, program elective course, multidisciplinary minor, IKS, PCE and vocational skill-enhanced course. Simultaneously, the objectives of NEP 2020 demand nurturing the core program, elective program, communication skills and skills required for the Electronics and Computer Engineering Branch of engineering in the learner. Keeping this in view, a pool of courses is offered in Core Courses covering fundamentals required to understand core and modern engineering practices and emerging trends. Elective courses are offered to the learners to understand the concepts of emerging technology. This will help with the holistic development of learners through interdisciplinary skills development and mobility among other departments as real-time solutions. Considering the shift in pedagogy and the convenience of a stress-free learning process, a choice-based subject pool is offered in the coursework under the heads of Electronics and Computer Engineering for open electives and multidisciplinary minor courses in sem V and VI. Essentially, to give a glimpse of trends in the industry under vocational and enhanced skill practices, the pool is offered to nurture and develop creative skills in contemporary industrial practices. Criteria met in the structure is the opportunity for learners to choose the course of their interest in all disciplines.

Program Core Course and Program Elective Courses Cover Electronics and Computer Engineering core and elective courses. Also, MDM is where a pool of subjects is given for selection. In addition to this learner will have IKS and PCE courses. Considering the present scenario, diverse choices need to be made available to fulfil the expectation of a learner to aspire for a career in the field of current trends of Technology and interdisciplinary research. The IKS course will be program-specific, which can be achieved in Undergraduate training by giving an objective viewpoint to the learning technology, from ascent time and how it was learned and the process and transitioning a learner from a rote learner to a creative professional. For this purpose, PCE is introduced in the First Semester to orient a communication skill to become skilled professionals for placement and higher education entrance exams. Considering the NEP-2020 structure of award of Certificate after U.G. First Year, U. G. Diploma after the Second Year and B.Sc. Tech Engineering after the Third Year at multiple exit-point pools of Vocational skills, is arranged to give exposure to the current Industry practices.

The faculty resolved that course objectives and course outcomes are to be clearly defined for every core and elective course so that all faculty members in affiliated higher education institutes understand the depth and approach of the course to be taught to the learners, which will enhance the learners' learning process. NEP 2020 grading system enables a much-needed shift in focus from teacher-centric to continuous-based learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on the holistic development of the learners through mobility and continuous evaluation, which will enhance the quality of education. Credit assignment for courses is based on a 15-week teaching-learning process for NEP 2020; however, the content of courses is to be taught in 12-13 weeks, and the remaining 2-3 weeks are to be utilized for revision, self-learning, tutorial, guest lectures, coverage of content beyond the syllabus, etc.

There was a concern that in the present system, the third-year syllabus must not be heavily loaded for the learner and it is of utmost importance that the learner entering the third year of an engineering course should feel at ease by lowering the burden of syllabus and credits. This is necessary for a learner to get accustomed to the new environment of a college and to create a bond between the teacher and the learner. The present curriculum will be implemented for the Third Year of Engineering from the academic year 2026-27. Subsequently, this system will be carried forward for Final Year Engineering in the academic years 2027-28, respectively.

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B.Sc. Tech Engineering- Electronics and Computer Engineering

Credit Structure (Sem. V & VI)

	R: _____C								
Level	**Semester**	**Major**		**Minor**	**OE**	**VSC, SEC (VSEC)**	**AEC, VEC, IKS**	**OJT, FP, CEP, CC, RP**	**Cum. Cr. / Sem.**	**Degree/ Cum. Cr.**
		Mandatory	**Electives**							
5.5	V	PCC501:3 PCC502:3 PCC503:3 PCL501: 1 PCL502:1 PCL503:1	PEC501:3 PEL501:1	MDC:3 MDL:1	OE:2	--	IKS: 2	--	24	**B.Sc. Tech Engineering 48**
	R:_____D									
	VI	PCC601:3 PCC602:3 PCL601:1 PCL602:1	PEC601:3 PEC602:3 PEL601:1 PEL602:1	MDC: 3 MDL:1	--	VSEC:2	AEC: 2	--	24	
	Cum Cr.	20	12	8	2	2	*2+2*	--	48	

Exit option: Award of UG Diploma in Major and MDM with 90 credits and additional 4 credits core **one** theory subject with 3 credits and **one** lab with 1 credit from one third year from where they want to take Exit degree. Along with theory and practical course student must compulsory do internship for **one month or 160 hours** which internship is equal to 4 credits.

[Abbreviation - OE – Open Electives, VSC – Vocation Skill Course, SEC – Skill Enhancement Course, (VSEC), AEC – Ability Enhancement Course, VEC – Value Education Course, IKS – Indian Knowledge System, OJT – on Job Training, FP – Field Project, CEP – Continuing Education Program, CC – Co-Curricular, RP – Research Project]

Sem. - V

T.E. Electronics and Computer Engineering Scheme

Program Structure for Third Year of Electronics and Computer Engineering

UNIVERSITY OF MUMBAI (With Effect from 2026-2027)

SEMESTER V

Course Code	Course Description	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Practical	Tutorial	Theory	Tutorial	Practical	Total Credits
2275111	Control System	3	--	--	3	--	--	3
2275112	Computer Network	3	–	--	3	--	--	3
2275113	Software Engineering	3	--	--	3	--	--	3
2275114	PEC-1	3	--	--	3	--	--	3
2275211	Embedded System and RTOS	3	--	--	3	--	--	3
2275115	Control System Lab	--	2	--	--	--	1	1
2275116	Computer Network Lab	--	2	--	--	--	1	1
2275117	Software Engineering Lab	--	2	--	--	--	1	1
2275118	PEL-1 lab.	--	2	--	--	--	1	1
2275212	Embedded System and RTOS Lab	--	2@	--	--	--	1	1
2275311	Industrial Automation	2#	--	---	2	--	--	2
2275511	IKS as per Groups	--	2*+2	--	--	--	2	2
Total		**17**	**14**	**00**	**17**	**00**	**07**	**24**

* Two hours of practical class to be conducted for full class as demo/discussion.

Theory / Tutorial 1 credit for 1 hour and Practical 1 credit for 2 hours

Institute shall offer a course for Open Elective from Science/Commerce/Management stream bucket provided by the University of Mumbai.

@ Institute shall offer a course for MDM from other Engineering Boards Group.

Course Code	**Course Description**
22751141	Semiconductor Devices and Characteristics
22751142	Machine Learning
22751143	DBMS
22751144	DATA COMPRESSION
Lab Code	**Lab Description**
22751181	Semiconductor Devices and Characteristics
22751182	Machine Learning Lab
22751183	DBMS
22751184	DATA COMPRESSION

course Code	Course Description	Examination scheme							
		Internal Assessment Test (IAT)			End Sem. Exam Marks	End Sem. Exam Duration (Hrs)	Term Work (Tw)	Oral & Pract.	Total
		IAT-I	IAT-II	Total (IAT-I) + IAT-II)					
2275111	Control System	20	20	40	60	2	--	--	100
2275112	Computer Network	20	20	40	60	2	--	--	100
2275113	Software Engineering	20	20	40	60	2	--	--	100
2275114	PEC-1	20	20	40	60	2	--	--	100
2275211	Embedded System and RTOS	20	20	40	60	2	--	--	100
2275115	Control System Lab	--	--	--	--	--	25	--	25
2275116	Computer Network Lab	--	--	--	--	--	25	25	50
2275117	Software Engineering Lab	--	--	--	--	--	25	25	50
2275118	PEL-1 lab.	--	--	--	--	--	25	25	50
2275212	Embedded System and RTOS Lab	--	--	--	--	--	25	25	50
2275311	Industrial Automation	--	--	--	--	--	50	--	50
2275511	IKS as per Groups						50	--	50
Total		**100**	**100**	**200**	**300**	**10**	**225**	**125**	**825**

Program Structure for Third Year of Electronics and Computer Engineering

UNIVERSITY OF MUMBAI (With Effect from 2026-2027)

SEMESTER VI

Course Code	Course Description	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Practical	Tutorial	Theory	Tutorial	Practical	Total Credits
2276111	Analog and Digital Communication	3	--	--	3	--	--	3
2276112	Artificial Intelligence	3	--	--	3	--	--	3
2276113	PE-2(Program Elective) *	3	--	--	3	--	--	3
2276114	PE-3(Program Elective) *	3	--	--	3	--	--	3
2276211	IOT	3	--	--	3	--	--	3
2276411	Mini-Project – II	--	4	--	--	--	2	2
2276611	Data Structures	--	2*+2	--	--	--	2	2
2276115	Analog and Digital Communication Lab	--	2	--	--	--	1	1
2276116	Artificial Intelligence Lab	--	2	--	--	--	1	1
2276117	PEL-2	--	2	--	--	--	1	1
2276118	PEL-3	--	2	--	--	--	1	1
2276212	IOT Lab	--	2@	--	--	--	1	1
Total		**15**	**18**	**00**	**15**	**00**	**09**	**24**

* Two hours of practical class to be conducted for full class as demo/discussion.

Theory / Tutorial 1 credit for 1 hour and Practical 1 credit for 2 hours

@ Institute shall offer a course for MDM from other Engineering Boards.

Course Code	Course Description
22761131	ASIC
22761132	Machine Learning
22761133	ADBMS
22761134	NETWORK AND SECURITY
22761141	MEMS & Automation
22761142	Signals and Image Processing
22761143	Cryptography
22761144	Computer Communication Network
Lab Code	**Lab Description**
22761171	ASIC
22761172	Machine Learning
22761173	ADBMS
22761174	NETWORK AND SECURITY
22761181	MEMS & Automation
22761182	Signals and Image Processing
22761183	Cryptography
22761184	Computer Communication Network

Course Code	Course Description	Examination scheme							
		Internal Assessment Test (IAT)			End Sem. Exam Marks	End Sem. Exam Duration (Hrs)	Term Work (Tw)	Oral & Pract.	Total
		IAT-I	IAT-II	Total (IAT-I) + IAT-II)					
2276111	Analog and Digital Communication	20	20	40	60	2	--	--	100
2276112	Artificial Intelligence	20	20	40	60	2	--	--	100
2276113	PE-2(Program Elective) *	20	20	40	60	2	--	--	100
2276114	PE-3(Program Elective) *	20	20	40	60	2	--	--	100
2276211	IOT	20	20	40	60	2	--	--	100
2276411	Mini-Project – II	--	--	--	--	--	50	--	50
2276611	Data Structures	--	--	--	--	--	25	--	25
2276115	Analog and Digital Communication Lab	--	--	--	--	--	25	25	50
2276116	Artificial Intelligence Lab	--	--	--	--	--	25	25	50
2276117	PEL-2	--	--	--	--	--	25	25	50
2276118	PEL-3	--	--	--	--	--	25	25	50
2276212	IOT Lab	--	--	--	--	--	25	25	50
Total		**100**	**100**	**200**	**300**	**10**	**200**	**125**	**825**

Vertical – 1
Major

Course Code	Course Name	Theory (Hrs.)	Practical (Hrs.)	Tutorial (Hrs.)	Theory (Credits)	Practical/ Oral (Credits)	Tutorial (Credits)	Total (Credits)
2275111	Control System	3	--	--	3	--	--	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		1	2	Average					
2275111	Control System	40	40	40	60	—	---	----	100

Prerequisite: Applied Mathematics (Laplace Transform, Ordinary differential equations), Applied Physics, Basic Electrical Engineering

Course Objectives:

1. To calculate the mathematical models of a given system using block diagram reduction rules and Mason's gain formula.
2. To provide fundamental concepts of control system such as Time response and Frequency response.
3. To develop concepts of stability and its assessment criteria.
4. Design performance specification-based controller for a given system.
5. To develop the concept of stability and its assessment for linear-time-invariant systems.
6. To introduce the design of controllers in frequency-domain and state-space.

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

1. Determine the mathematical models of a given system using block diagram reduction rules and Mason's gain formula.
2. Analyze the performance of first order and second order control systems based on the time domain and frequency domain specifications.
3. Evaluate the stability of the control systems in time domain and frequency domain.
4. Design performance specification-based controller for a given system.
5. Analyze the control systems using state-space methods and design state feedback controllers.
6. Design performance specification-based controller for a given system.

DETAILED THEORY SYLLABUS:

Sr. No.	Module	Detailed Content	Hrs.
1.	**Introduction to Control System**	Examples of control systems; open and closed loop systems; Servomechanism. Mathematical modeling of Electrical & Mechanical Systems; Transfer function model. Block diagram and Signal Flow Graph (SFG) representation of control systems; Block diagram reductions; Mason's gain formula.	**08**
2	**Time Response Analysis**	Standard test input signals; time response of first and second order systems for standard test inputs; Transient response specification for second order system; Error constants and type of the system. Effect of Damping, Time Response Specifications: Delay time, Rise time, Peak Time, Peak Overshoot, settling time, Numerical Problems.	**08**
3	**Stability Analysis in Frequency Domain**	Stability in time domain: The concept of stability, necessary conditions for stability, Hurwitz stability criterion, Routh stability criterion, relative stability analysis. Root locus Analysis: Root locus concept, general rules for constructing root-locus, root locus analysis of control system.	**07**
4	**Frequency Response Analysis**	Introduction to frequency response; Frequency response plots: Polar plot and Bode plot; Stability margins in frequency domain, Nyquist stability criterion and stability analysis using Nyquist plot.	**07**
5	**Introduction to Controller Design and State-space Analysis**	Characteristics of feedback: Sensitivity to parametric variation; Disturbance rejection; Steady-state accuracy. Feedback controller design using Root-locus; Reshaping the root-locus; Cascade lead, lag and lag-lead compensator. Concept of state variables; State-space model; Canonical forms; Conversion between canonical forms using similarity transforms. Solution of state-space equation; Eigen-values and eigenvectors; Stability in state-space; Concept of controllability and observability.	**08**
6	**Controller Design in State-space**	State-feedback controller design: Pole-placement method; Ackerman's formula.	**04**

Theory Assessments:

1. Internal Assessment: Two Internal assessments will be conducted for 40 marks each with average marks of both assessments as final score.

2. End Sem Theory Examination:

- Question paper will consist of 4 questions, each carrying 20 marks.
- Total 3 questions need to be solved.
- Q.1 will be compulsory, based on the entire syllabus.
- Remaining questions will be randomly selected from all the modules.

Weightage of marks should be proportional to the number of hours assigned to each module.

Books:

1. K. Ogata, "Modern Control Engineering", PHI, New Delhi

2. I. J. Nagrath, M. Gopal, "Control System Engineering", 5th edition, New Age International Publishers

Reference Books:

1. Golnaraghi Farid, B. C. Kuo, "Automatic Control Systems", 10th edition, McGraw Hill, 2017.

2. K. Ogata, "Modern Control Engineering", 6th edition, Prentice Hall, 2010.

3. I.J. Nagrath, M. Gopal, "Control System Engineering", New Age International, 2009.

4. Norman Nise, "Control Systems Engineering", Wiley, 8th edition, 2019.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
2275115	Control Systems Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
		Term work		Orals			Total	
		25		25			50	

COURSE OBJECTIVES:

1.To study the system performance using time domain analysis and methods for improving it.
2.To assess the system performance using frequency domain analysis and techniques for improving the performance to design various controllers and compensators to improve system performance.
3.To design various controllers and compensators to improve system performance.
4.To study the characteristics of servo mechanisms which are helpful in automatic control systems.
5.To understand the different ways of system representations such as transfer function representation and state space representations and to assess the system dynamic response.

COURSE OUTCOMES:

At the end of the course, students would be able to:

1. Determine the performance and time domain specifications of first order systems.
2. Analyze various time domain and frequency domain techniques to assess the system performance.
3. Study the system performance by selecting a suitable controller and/or a compensator for a specific application.
4. Get the knowledge about the effect of poles and zeros location on transient and steady state behavior of second order systems and can implement them to practical systems.
5. Study system controllability and observability using state space representation and applications of state space representation to various systems.

Laboratory Experiments:

PART-A

The following experiments are required to be conducted compulsory experiments:
1. Time response of Second order system
2. Characteristics of Synchros
3. Effect of feedback on DC servomotor
4. Transfer function of DC motor
5. Transfer function of DC generator
6. Temperature controller using PID
7. Characteristics of AC servomotor
8. Effect of P, PD, PI, PID Controller on a second order systems

PART-B

In addition to the above eight experiments, at least any two of the experiments from the Following list are required to be conducted.

9. Lag and lead compensation – Magnitude and phase plot
10. Programmable logic controller – Study and verification of truth tables of logic gates, Simple Boolean expressions and application of speed control of motor.
11. a) Simulation of P, PI, PID Controller.
12. b) Linear system analysis (Time domain analysis, Error analysis) using suitable software
13. Stability analysis (Bode, Root Locus, Nyquist) of Linear Time Invariant system using Suitable software
14. State space model for classical transfer function using suitable software – Verification.
15. Design of Lead-Lag compensator for the given system and with specification using Suitable software

Laboratory Assessment:

Assessment:

Term Work: Term Work shall consist of at least 10 to 11 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical/ Oral Exam: An Oral examination will be held based on the above syllabus.

Term Work:

At least 10 experiments covering the entire syllabus of should be set to have well predefined inference and conclusion. The experiments should be student centric and attempts should be made to make the experiments meaningful and interesting. Experiments must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Note:

Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
2275112	Computer Network	L	T	P	L	T	P	Total
		3	--	2	3	--	1	4
		Examination Scheme						
			IA1	IA2	ESE		Total	
		Theory	20	20	60		100	

Pre-requisite Course Codes	PC303 Computer Organisation and Architecture	
Course Outcomes	After the successful completion students should be able to	
	CO1	Describe the architecture, services, and protocol hierarchies of computer networks.
	CO2	Explain physical layer transmission media and demonstrate the role of network devices in communication.
	CO3	Analyze data link layer design issues and apply error detection, flow control, and MAC protocols.
	CO4	Compute IP addressing schemes and evaluate routing algorithms for efficient network design.
	CO5	Differentiate between TCP and UDP services and implement flow and congestion control mechanisms.
	CO6	Illustrate application layer protocols and develop client-server communication scenarios.

Module No.	Unit No.	Topics	Reference	Hrs.
Module 1	1	Introduction to Data Communications and Networking	T1, T2, R1, R4	6Hrs
	1.1	Introduction to computer networks, Network software, Layers and services, Network topologies, protocol hierarchies, design issues for the layers, connection oriented and connectionless services.		
	1.2	Reference models: Layer details of OSI, TCP/IP models. Communication between layers. Internet		
	1.3	Addressing: physical/logical/port addressing/socket addressing.		
Module	2	Physical Layer	T1, T2,	5

2	2.1	Guided Transmission Media: Twisted pair, Coaxial, Fiber optics.	R2, R3	Hrs
	2.2	Unguided media (Wireless Transmission): Radio Waves, Microwave, Bluetooth, Infrared, Circuit and Packet Switching.		
	2.3	Network Devices: Repeaters, Hubs, Switches, Routers and Gateways		
Module 3	3	Data Link Layer	T1, T2, R1, R4	8Hrs
	3.1	DLL Design Issues - Services, Framing, Error Control, Flow Control, Error Detection and Correction, Elementary Data Link Protocols, Stop and Wait, Sliding Window - Go Back N, Selective Repeat.		
	3.2	Medium Access Control sublayer: Channel Allocation problem, Multiple access Protocol (Aloha, Carrier Sense Multiple Access (CSMA/CD), Local Area Networks - Ethernet (802.3), Introduction to wireless LAN: 802.11x		
Module 4	4	Network Layer	T1, T2, R1, R2, R4	10 hrs
	4.1	Network Layer design issues, Communication Primitives: Unicast, Multicast, Broadcast. Network Layer Protocols: IPv4 Datagram Format, IPv4 Addresses, IPv4 Addressing (classfull and classless), Sub-netting and Super-netting design problems, IPv4 Protocol, IPv6 Packet Format, IPv6 Addressing, Transition from IPv4 to IPv6.		
	4.2	Routing algorithms: Intra-domain Routing -Shortest Path, Distance Vector Algorithms, Link State Routing, Inter-domain Routing Protocols.		
	4.3	Introduction to ICMP, ARP, RARP		
Module 5	5	Transport Layer	T1, T2, R1, R4	6 hrs
	5.1	Connectionless and Connection–oriented services at transport layer, Transmission Control Protocol (TCP): TCP Services, TCP Segment, TCP three-way handshake.		
	5.2	User datagram Protocol (UDP), UDP Services, UDP Datagram		
	5.3	TCP Flow control, error control and congestion control		
Module 6	6	Application Layer	T1, T2, R1	4 hrs
	6.1	Application layer Paradigms, Client-Server Paradigm: Application Programming Interface		
	6.2	Introduction to Application layer Protocols: HTTP, FTP, DNS, SMTP, TELNET, SSH, DHCP.		
Total				39

Course Assessment:

Theory:

IA1: 20 Marks written examination for one hour
IA2: 20 Marks written examination for one hour
ESE: 60 Marks written examination for two hours

Recommended Books:

Textbooks:

1. Andrew S Tanenbaum, Computer Networks -, 5th Edition, Pearson Education
2. Behrouz A. Forouzan, Forouzan Mosharrat, Computer Networks A Top down Approach, McGraw Hill education
3. Ranjan Bose, Information Theory, Coding and Cryptography, Ranjan Bose, Tata McGraw Hill, Second Edition

Reference books:

1. James F. Kurose, K. W. Ross, Computer Networking: A Top-Down Approach Featuring the Internet, 3rd Edition, Pearson Education.
2. S. Keshav, An Engineering Approach to Computer Networks, 2nd Edition, Pearson Education.
3. W. A. Shay, Understanding Communications and Networks, 3rd Edition, W. A. Shay, Cengage Learning.
4. L. L. Peterson and B. S. Davie, Computer Networks: A Systems Approach, 4th Ed, Elsevier India

Online References:

1. NPTEL – Computer Networks (Prof. Bhaskaran Raman / Prof. Rajesh Sundaresan)
   https://nptel.ac.in/courses/106/105/106105081
2. Cisco Networking Academy – Introduction to Networks (Free Modules)
   https://www.netacad.com/courses/networking
3. RFC Repository for Internet Standards
   https://www.rfc-editor.org
4. IETF (Internet Engineering Task Force) – Protocol Standards and drafts
   https://www.ietf.org

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
2275116	Computer Network Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
		Term work		Orals			Total	
		25		25			50	

Pre-requisite Course Codes		
Laboratory Objectives	1.	To analyze network protocols and packet structures using tools like Wireshark.
	2.	To practice basic networking commands and physical cable preparation for LAN connectivity.
	3.	To configure and compare network topologies and hardware components using simulation tools.
	4.	To implement static and dynamic routing protocols for efficient network communication.
	5.	To perform subnetting, IP addressing, and socket programming for data transmission.
	6.	To configure firewalls and routing tables for secure network operations
Laboratory Outcomes	After the successful completion students should be able to	
	LO1	Analyze TCP/IP stack and interpret protocol headers and encapsulation.
	LO2	Execute networking commands and prepare/test UTP cables for LAN connectivity.
	LO3	Configure and compare network topologies and hardware components using Cisco Packet Tracer.
	LO4	Implement static and dynamic routing protocols (RIP, OSPF, BGP, EIGRP) and verify routing tables.
	LO 5	Perform subnetting, configure IP addressing schemes, and develop socket programs for TCP/UDP.
	LO 6	Configure firewalls and manage routing tables for secure network operations.

Laboratory Experiments:

Sr. No.	Title of experiment	Hardware /Software	Module	Reference
1.	Analysis of TCP/IP Stack Using Packet Capturing Tool (Wireshark)	Software	1	1, 5
2.	Study and Execution of Basic Networking Commands in Linux	Software	2	2, 7
3.	Configuration and Comparison of Network Topologies Using Cisco Packet Tracer	Software	2	2, 3, 6
4.	Configuration and Comparison of Network Hardware Components Using Cisco Packet Tracer	Software	3	2, 3, 6
5.	Configuration of Static Routing in a Network Using Cisco Packet Tracer	Software	3	3, 6
6	Configuration of Distance Vector Routing Protocol (RIP)	Software	3	3, 6
7	Configuration of Link State Routing Protocol (OSPF)	Software	4	3, 6
8	Configuration of Path Vector Routing Protocol (BGP)	Software	4	3, 6
9.	Implementation of Subnetting and IP Addressing	Software	4	1, 2, 6
10.	Implementation of Socket Programming Using TCP and UDP	Software	4	1, 4
11.	Configuration of Firewall Using IP Tables	Software	5	7

Laboratory Assessment:
Assessment:
Term Work: Term Work shall consist of at least 10 to 11 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.
Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)
Practical/ Oral Exam: An Oral examination will be held based on the above syllabus.

Recommended Books:

1. Computer Networking: A Top-Down Approach, Pearson Education.
   (Useful for TCP/IP, socket programming, protocol analysis)
2. Hands-On Networking Fundamentals, Cengage Learning.
   (Useful for practical networking concepts and network devices)
3. Network Simulator Experiments Manual
   (Useful for simulation-based networking experiments)
4. TCP/IP Sockets in C, Morgan Kaufmann.
   (Useful for TCP/UDP socket programming experiments)
5. Practical Packet Analysis, No Starch Press.
   (Useful for Wireshark and packet analysis experiments)

6. CCNA 200-301 Official Cert Guide, Cisco Press.
   (Useful for routing, switching, RIP, OSPF, BGP practicals)
7. Linux Firewalls, Novell Press.
   (Useful for IPTables and firewall configuration)

Online Resources:

· https://www.netacad.com/9tut.com – CCNA Tutorials & Labs

Term Work:

At least 10 experiments covering the entire syllabus of PCL 502 (Computer Network Lab) should be set to have well predefined inference and conclusion. The experiments should be student centric and attempts should be made to make the experiments meaningful and interesting. Experiments must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Note:

Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
2275113	Software Engineering	L	T	P	L	T	P	Total
		2	--	--	2	--	1	3
		Examination Scheme						
			IA1	**IA2**	**ESE**		**Total**	
		Theory	20	20	60		100	

Pre-requisite Course	1.Knowledge of Software Application Domains, Software Engineering Practices. 2. Knowledge of any Programming Language	
	After the successful completion students should be able to	
Course Outcomes	CO1	To learn basics of software engineering & software development process models, agile software development & other agile practices.
	CO2	To Identify, Specify, analyse Software Requirements and prepare models.
	CO3	To understand concepts and principles of software design and Development.
	CO4	To learn about Project Scheduling concept and Software Cost Estimation Techniques.
	CO5	To understand the concept of software quality assurance and Risk Management.
	CO6	To learn different software testing strategies and tactics.

Module No.	Unit No.	Topics	Reference	Hrs.
Module 1	**1**	**Introduction to Software Engineering and Process Models**		6Hrs
	1.1	Nature of Software, Software Process framework	1,2	
	1.2	Prescriptive Models: Waterfall Model, Incremental, RAD Models Evolutionary Process Models: Prototyping, Spiral and Concurrent Development Model. Specialized Models: Component based		
	1.3	Agile process, Agility Principles, Extreme Programming (XP), Scrum.		

Module 2	**2**	**Requirement Engineering and Modelling**		8Hrs
	2.1	Types of Requirements, Requirement Engineering Task, Software Requirement Specification (SRS), Developing Use Cases (UML)	1,2	
	2.2	Requirement Model: Scenario-based model, Class-based model, Behavioural model.		
Module 3	**3**	**Design Engineering**	1,2 3	6 Hrs
	3.1	Design Process, Software design principles, Design Concepts, Characteristics of Good Design,Effective Modular Design – Cohesion and Coupling.		
	3.2	Software Architecture, architectural Genres, user interface design principles.		
Module 4	**4**	**Project scheduling & Cost Estimation**		8 Hrs
	4.1	Project Scheduling, defining a Task Set for the Software Project, Gantt charts, Program Evaluation Review Techniques (PERT), Tracking the Schedule	1,2 ,3	
	4.2	Software Project Estimation, Decomposition Techniques, LOC based, FP based and Use case-based estimations, Empirical estimation Models. COCOMO II Model.		
Module 5	**5**	**Software Risk &vQuality Management**		
	5.1	Software Risk, Types of Risk, Risk Identification, Risk Assessment, Risk Projection, RMMM	1,2,3	5Hrs
	5.2	Software Quality Assurance Task and Plan, McCall's Quality Factors, Software Reliability, Formal,Technical Review (FTR), Walkthrough		
Module 6	**6**	**Software Testing Strategies and Tactics**		6Hrs
	6.1	Software Testing Fundamentals, Testing strategies for conventional and Object-Oriented architectures, Unit testing, Integration testing, System Testing, Validation and System Testing	1,2,3	
	6.2	Testing Tactics: White-Box Testing, Basis Path Testing, Control Structure Testing, Black-Box Testing		
Total				**39**

Course Assessment:

Theory:

IA1: 20 Marks written examination for one hour
IA2: 20 Marks written examination for one hour

ESE: 60 Marks written examination for two hours

Recommended Books:

[1] Roger S Pressman “Software Engineering: A Practitioner’s Approach” 8th Edition McGraw-Hill.
[2] Rajib Mall, "Fundamentals of Software Engineering", Prentice Hall India.
[3] Pankaj Jalote, "An integrated approach to Software Engineering", Springer/Narosa

Online References:
NPTEL courses on Software Engineering

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
2275117	Software Engineering Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
		Term work		Orals			Total	
		25		25			50	

Pre-requisite Course Codes	Nil	
Laboratory Objectives	1.	To understand and apply software process models
	2	To develop software requirement and design models using UML
	3.	To perform software project planning and estimation techniques
	4.	To implement software quality assurance and testing techniques
Laboratory Outcomes	After the successful completion students should be able to	
	LO1	Identify requirements and apply process models to selected case studies.
	LO2	Analyse and design models for the selected case study using UML modeling
	LO3	Use various Software Engineering and Project Management Tools
	LO4	Create project schedule, estimate budget and RMMM plan
	LO 5	Design test cases for achieving software quality.

Laboratory Experiments:

Sr. No.	Title of experiment	Hardware /Software	Module	Reference
1.	Compare various SDLC models and justify the selection of an appropriate model to solve a given problem statement.	Software	1	1,2,3
2.	Develop a basic Software Requirement	Software	2	1,2,3

	Specification (SRS) for a specified software application			
3.	Design Use case diagrams for given problem statements using star UML.	Software	2	1,2,3
4.	Design DFD diagram for given problem statement using online tools like star UML.	Software	2	1,2,3
5.	Develop Activity / State Transition diagram for the project.	Software	2	1,2,3
6.	Develop Class diagram /sequence diagram for the project.	Software	2	1,2,3
7.	Prepare a schedule for the project using any project management tool like project Libre .	Software	4	1,2,3
8.	Perform Cost Estimation of Software.	Software	4	1,2,3
9.	Prepare a RMMM plan for the project.	Software	5	1,2,3
10.	Develop test cases for the project using white box testing.	Software	6	1,2,3
11.	Design test cases for the project using black box testing .	Software	6	1,2,3
12	Develop a small working prototype based on a selected case study.	Software	1,2,3,4,5,6	1,2,3

Laboratory Assessment:
Assessment:
Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.
Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)
Practical/ Oral Exam: An Oral examination will be held based on the above syllabus.

Recommended Books:

[1] Ian Sommerville, "Software Engineering", Pearson Education (9th edition)
[2] Jibitesh Mishra and Ashok Mohanty, "Software Engineering", Pearson edition
[3] Hans Van Vliet "Software Engineering Principles and Practice" 3rd edition Wiley.

Term Work:

At least 10 experiments covering the entire syllabus of PCL 602 (Software Engineering Lab) should be set to have well predefined inference and conclusion. The experiments should be student centric and attempts should be made to make the experiments meaningful and interesting. Experiments must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Note:

Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
2276111	Analog and Digital Communication	L	T	P	L	T	P	Total
		3	--	2	3	--	1	4
		Examination Scheme						
			IA1	IA2	ESE		Total	
		Theory	20	20	60		100	

Pre-requisite Course Codes		PCC 201X Digital Electronics**,** PCC 301 Signals and Systems, PCC 302 Electronic Devices, PCC402 Analog Electronics
Course Outcomes	After the successful completion students should be able to	
	CO1	Explain fundamentals of communication systems, noise, and modulation techniques.
	CO2	Analyze AM, FM, and PM modulation and demodulation systems.
	CO3	Apply sampling, pulse modulation, and multiplexing techniques in communication systems.
	CO4	Explain source coding and channel coding methods for reliable communication.
	CO5	Analyze baseband and digital bandpass transmission techniques and their performance.
	CO6	Compare communication and modulation techniques for practical applications.

Module No.	Unit No.	Topics	Reference	Hrs.
Module 1	**1**	**Introduction to Communication Systems**	1,2,3,4,6	5 Hrs
	1.1	Electromagnetic Spectrum, Block diagram of analog and digital communication system, Need for modulation		
	1.2	Types of Noise, Signal-to-noise ratio, Noise factor, Noise Figure, Noise Temperature, Friis Formula		
Module 2	**2**	**Analog Modulation and Demodulation Techniques**		
	2.1	**Amplitude Modulation and Demodulation-** Mathematical and Graphical Representation AM wave, Voltage distribution and Power Calculations. Basic Concepts of DSBSC and SSB. AM Diode Detectors	1,2,3,4,6	10 Hrs
	2.2	**Frequency and Phase Modulation and Demodulation** - Mathematical Representation of FM wave, deviation ratio, bandwidth requirement, Narrowband and Wideband FM, Pre-emphasis and De-emphasis, Noise-triangle, FM Generation (Varactor Diode and Armstrong method) , FM Detectors- Foster-Seeley Detector, Phase Modulation, Applications and Comparison of AM, FM and PM		
	2.3	**Radio Receivers** – Characteristics of radio receivers, Super heterodyne AM and FM receivers, AGC		
Module 3	**3**	**Pulse Modulation and Multiplexing Techniques**		
	3.1	Sampling Theorem, Nyquist Criteria, Sampling Techniques, Aliasing error and Aperture effect	2,3,4,6,7	7 Hrs
	3.2	Generation and Detection of PAM, PWM and PPM. PCM Transmitter and Receiver. Concepts of Delta modulation (DM) and Adaptive Delta Modulation (ADM).		

	3.3	Need of Multiplexing, Block Diagram explanation of TDM and FDM Systems		
Module 4	**4**	**Source Coding and Channel Coding**	4,5,6,7	6 Hrs
	4.1	Basics of Information Theory, Entropy, Shannon Hartley theorem, Source Coding Techniques: Huffman coding and Shannon-Fano coding		
	4.2	Channel Coding for Error Detection and Correction - Linear Block Codes, Cyclic Codes and Convolutional Codes		
Module 5	**5**	**Baseband Transmission and Reception**	4,5,6,7	4 Hrs
	5.1	Block diagram of baseband Transmitter-Receiver system, Need of line codes, Properties, Types of line codes - RZ and NRZ Unipolar formats, RZ and NRZ Polar formats, RZ and NRZ Bipolar format (AMI format), Split phase Manchester format and Polar Quaternary formats		
	5.2	Inter Symbol Interference, Inter Channel Interference, Introduction to Matched Filter and Equalizer		
Module 6	**6**	**Bandpass Transmission and Reception**	4,5,6,7	7 Hrs
	6.1	Generation, Detection, Error probability, Power Spectral Density, Euclidean distance and Bandwidth of BASK, BFSK, BPSK		
	6.2	Generation, Detection, Error probability, Power Spectral Density, Euclidean distance and Bandwidth of QPSK, offset QPSK, M-ary PSK, 16-ary QASK and MSK.		
Total				**39**

Course Assessment:

Theory:

IA1: 20 Marks written examination for one hour

IA2: 20 Marks written examination for one hour

ESE: 60 Marks written examination for two hours

Recommended Books:

[1] Kennedy and Davis “Electronics Communication System”, Tata McGraw Hill

[2] Wayne Tomasi, “Electronics Communication Systems” Pearson Education, 5th Edition.

[3] Herbert Taub, Donald L Schilling, Goutam Saha, “Principles of Communication Systems”, Tata McGraw Hill, 3rd Edition.

[4] T. L. Singal, “Analog and Digital Communication,” Tata Mc-Graw Hill, New Delhi, First Ed.

[5] Sklar B, and Ray P. K., “Digital Communication: Fundamentals and Applications,” Pearson, Dorling Kindersley (India), Delhi, Second Edition

[6] Simon Haykin, “Communication System”, John Wiley and Sons,4th Ed.

[7] B P Lathi, Zhi Ding, Modern Digital and Analog Communication Systems, Oxford University. 4th Ed.

[8] Beharouz A. Forouzan, “Data Communication and Networking”, fourth edition

Online References:

1. Analog communication- https://swayam.gov.in/nd1_noc20_ee69/preview
2. Principles of Digital Communication- https://nptel.ac.in/courses/108/101/108101113/
3. Principles of Digital Communication- https://nptel.ac.in/courses/108/102/108102120/

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
2276115	Analog and Digital Communication Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
		Term work		Oral and Practical Exam			Total	
		25		25			50	

Pre-requisite Course Codes		
Laboratory Objectives	1.	To implement analog, pulse, and digital modulation and demodulation techniques.
	2	To study multiplexing, source coding, and channel coding techniques.
	3.	To analyze various line coding methods used in communication systems.
	4.	To use hardware and simulation tools for communication system analysis.
Laboratory Outcomes	After the successful completion students should be able to	
	LO1	Implement various analog modulation and demodulation techniques.
	LO 2	Implement pulse modulation, demodulation, and multiplexing techniques.
	LO 3	Implement digital modulation and demodulation techniques.
	LO 4	Analyze performance characteristics of communication systems and coding techniques.
	LO 5	Analyze different line coding techniques used in digital communication.
	LO 6	Simulate source coding and channel coding techniques for error control and data transmission.

Laboratory Experiments:

Sr. No.	Title of Experiment	Hardware / Software	Module	Reference
1	Generation and Detection of DSB-SC Signal	Hardware/Software	2	1,3,4
2	Generation and Detection of Frequency Modulation	Hardware/Software	2	1,3,4
3	Design and Implementation of Pre-emphasis and De-emphasis Circuit	Hardware/Software	2	1,3,6
4	Study of Superheterodyne Receiver Characteristics and AGC	Hardware/Software	3	1,2,3
5	Verification of Sampling Theorem	Hardware/Software	3	1,2,3
6	Generation and Detection of PAM Signals	Hardware/Software	3	1,2,3
7	Generation and Detection of PWM and PPM Signals	Hardware/Software	3	1,2,3,4
8	Generation and Detection of PCM Signals	Hardware/Software	3	1,2,3,4
9	Study of Delta Modulation and Adaptive Delta Modulation Techniques	Hardware/Software	3	1,2,4
10	Study of Time Division Multiplexing and De-multiplexing	Hardware/Software	3	1,2,4
11	Study of Frequency Division Multiplexing and De-multiplexing	Hardware/Software	4	4,5,7
12	Simulation of Shannon-Fano Coding and Calculation of Code Efficiency	Hardware/Software	4	4,5,7
13	Study of Huffman Coding and Calculation of Code Efficiency	Hardware/Software	4	4,5,7
14	Study of Linear Block Code and Analysis of Error Detection Capability	Hardware/Software	4	4,5,7
15	Study of Convolutional Code for Given Specifications	Hardware/Software	5	4,5,7
16	Observation and Comparison of Various Line Codes	Hardware/Software	5	5,6,7
17	Study of Matched Filter Response for a Given Input Signal	Hardware/Software	6	4,5,7
18	Study of Modulation and Demodulation of Binary ASK, FSK, and PSK	Hardware/Software	6	4,5,7
19	Study of Modulation and Demodulation of QPSK	Hardware/Software	6	4,5,7
20	Study of Modulation and Demodulation of MSK	Hardware/Software	6	4,5,7

Laboratory Assessment:

Assessment:

Term Work: Term Work shall consist of at least 10 to 12 practical's based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical/ Oral Exam: An Practical and Oral examination will be held based on the above syllabus.

Term Work:

At least 10-12 experiments covering the entire syllabus should be set to have well predefined inference and conclusion. This must include **50%** Hardware and **50%** Simulation experiments. The experiments should be student centric and attempts should be made to make the experiments meaningful and interesting. Experiments must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Note:

Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
2276112	Artificial Intelligence	L	T	P	L	T	P	Total
		3	--	--	3	--	-	3
		Examination Scheme						
			IA1	IA2	ESE		Total	
		Theory	20	20	60		100	

Pre-requisite Course Codes	Fundamentals of mathematics including probability and statistics, Understanding of data structures and algorithms	
Course Outcomes	After the successful completion students should be able to	
	CO1	Explain the fundamental concepts, scope, types, applications and current trends of Artificial Intelligence.
	CO2	Identify the characteristics of the environment and differentiate between various agent architectures
	CO3	Apply the most suitable search strategy to design problem solving agents.
	CO4	Represent a natural language description of statements in logic and apply the inference rules to design Knowledge Based agents.
	CO5	Apply probabilistic reasoning and Bayesian approaches to handle uncertainty in AI systems.
	CO6	Explain modern AI learning paradigms, Generative AI, LLMs, XAI and ethical aspects of AI systems.

Module No.	Unit No.	Topics	Reference	Hrs.
Module 1	**1**	**Introduction to Artificial Intelligence and Intelligent Agents**	1,2,3	5Hrs
	1.1	Definition, scope and history of Artificial Intelligence (AI), Different perspectives of AI, Scope of AI in modern computing and engineering.		
	1.2	Types of AI: Weak AI vs Strong AI, Narrow AI and General AI, Reactive machines, Super AI, Applications of AI, Current trends in AI.		
Module 2	**2**	**Intelligent Agents and Environment**	1,2,3 ,5,6	5 Hrs
	2.1	Definition of an intelligent agent, components of an agent, PEAS representation (Performance measure, Environment, Actuators and Sensors), Concept of rationality, types of agents: simple reflex, model-based, goal-based and utility-based agents, Learning Agent		
	2.2	Characteristics of environments: fully observable vs partially observable, deterministic vs stochastic, episodic vs sequential, static vs dynamic, discrete vs continuous, Competitive vs collaborative.		

Module 3	**3**	**Problem Solving & Search Techniques**	1,2,3 ,4,5	9Hrs
	3.1	State space representation: concept of problem solving in AI, definition of state space, representation using state space trees and graphs, examples: 8-puzzle and route finding. Performance measures of search algorithms: completeness, optimality, time complexity and space complexity		
	3.2	Uninformed search techniques: Breadth First Search (BFS), Depth First Search (DFS), Depth Limited Search (DLS), Iterative Deepening Search (IDS) and Uniform Cost Search (UCS). Informed search techniques: Greedy Best First Search, A* algorithm, heuristic functions and admissibility. Local search techniques: hill climbing and simulated annealing.		
	3.3	Game playing: minimax algorithm and alpha-beta pruning.		
Module 4	**4**	**Knowledge Representation & Reasoning**	4,5	8 Hrs
	4.1	Knowledge representation schemes, propositional logic (PL): basics of logic and statements, syntax and semantics, logical connectives, truth tables, conversion to conjunctive normal form (CNF). First Order Predicate Logic (FOPL): syntax and semantics, predicates, constants, variables, functions and quantifiers, representation of real-world knowledge.		
	4.2	Inference rules in FOPL, inference techniques: forward chaining, backward chaining and resolution in FOPL.		
Module 5	**5**	**Uncertainty & Probabilistic Reasoning**	3,4,5	5 Hrs
	5.1	Handling uncertain knowledge, random variables, joint, conditional and marginal probability, Bayes' theorem, concept of prior, likelihood and posterior probability.		
	5.2	Bayesian Belief Networks: Mathematical formulation and reasoning in belief networks.		
Module 6	**6**	**Modern AI Systems and Learning**	6,7,8 ,9	7 Hrs
	6.1	Concept of learning in AI, Overview of machine learning and deep learning, Concepts of Supervised, Unsupervised, Semi - Supervised Learning, Reinforcement Learning, Ensemble Learning.		
	6.2	Conversational AI: chatbots and virtual assistants, Generative AI and foundation models, Basics of prompt engineering, Overview of Large Language Models (LLMs)		
	6.3	Explainable AI (XAI): need for explainability, interpretability and transparency, Ethical issues, bias, privacy and limitations of modern AI systems		
			Total	**39**

Course Assessment:

Theory:

IA1: 20 Marks written examination for one hour
IA2: 20 Marks written examination for one hour

ESE: 60 Marks written examination for two hours

Recommended Books:

1. Stuart J. Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach,Second Edition" Pearson Education.
2. Elaine Rich and Kevin Knight ―Artificial Intelligence, Third Edition, Tata McGraw-Hill Education Pvt. Ltd., 2008.
3. George F Luger "Artificial Intelligence" Low Price Edition, Pearson Education., Fourth edition.
4. D. W. Patterson, Artificial Intelligence and Expert Systems, Prentice Hall.
5. Saroj Kaushik "Artificial Intelligence", Cengage Learning.
6. Deep Learning – Ian Goodfellow, Yoshua Bengio, Aaron Courville
   (Comprehensive deep learning reference, widely considered foundational)
7. Machine Learning for Absolute Beginners: A Plain English Introduction Book by Oliver. Theobald.
8. A Beginner's Guide to Generative AI: An Introductory Path to Diffusion Models, ChatGPT, and LLMs
9. Explainable Artificial Intelligence (XAI): Concepts, Taxonomies, Opportunities and Challenges toward Responsible AI

Online References:

1. NPTEL – Artificial Intelligence by Prof. Deepak Khemani (IIT Madras)

   https://nptel.ac.in/courses/106106126.
2. NPTEL – Introduction to Machine Learning by Prof. Balaraman Ravindran (IIT Madras)
   https://nptel.ac.in/courses/106106139
3. Coursera – Machine Learning by Andrew Ng (Stanford University)
   https://www.coursera.org/learn/machine-learning

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
2276116	Artificial Intelligence Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
		Term work		Orals			Total	
		25		25			50	

Pre-requisite Course Codes	**ESL 102 BEEE Lab, BSL2012 Semiconductor Physics Lab**	
Laboratory Objectives	1.	Develop practical understanding of intelligent agents, search techniques, knowledge representation, and reasoning methods used in Artificial Intelligence.
	2	Apply machine learning and probabilistic reasoning techniques for solving real-world AI problems.
	3.	Implement and evaluate AI algorithms using suitable programming tools and frameworks.
	4.	Explore modern AI applications including conversational AI, generative AI, and Large Language Models (LLMs).
Laboratory Outcomes	After the successful completion students should be able to	
	LO1	Analyze AI problems using PEAS description, task environments, and suitable intelligent agent architectures.
	LO2	Implement basic AI problem-solving techniques using uninformed and informed search algorithms.
	LO3	Represent knowledge using PROLOG and First Order Predicate Logic (FOPL) and perform logical inference.
	LO4	Apply probabilistic reasoning and Bayesian Networks for reasoning under uncertainty.
	LO 5	Use modern AI tools, LLMs and pretrained transformer models for generative AI applications.
	LO6	Analyze real-world AI systems with respect to functionality, performance and practical applications.

Laboratory Experiments:

Sr. No.	Title of experiment	Hardware /Software	Module	Reference
1	Write a simple program to provide the PEAS description and TASK Environment for a given AI problem and Identify suitable Agent Architecture for the problem	Logical	**1**	**1,2**
2	Design Vacuum Cleaner as reflex based and Model -Based Reflex Agent.	Python	**2**	**1,2**
3	Write basic PROLOG programs using facts and simple queries to understand syntax and execution.	PROLOG Software	**4**	**3**
4.	Implement any one of the Uninformed search techniques	Python/Virtual Lab	**3**	**1,2**
5.	Implement any one of the Informed search techniques	Python/Virtual Lab	**3**	**1,2**
6	Implement any one of the Local Search techniques. e.g. Hill Climbing, Simulated Annealing.	Python/Virtual Lab	**3**	**1,2**
7.	Convert the given statements in FOPL and draw inference from it using Resolution.	Software	**4**	**1,2**
8	Create a Bayesian Network for the given Problem Statement and draw inferences from it.	Software	**5**	**1,2**
9	Implement adversarial search using min-max algorithm.	Software	**3**	**1,2**
10.	Use an LLM interface/API to test different prompts	Software	**6**	**4**
11.	Generate text summaries, emails, or stories using pretrained transformer models	Software	**6**	**4**
12	Case study of any existing successful AI system	Software	**6**	

Laboratory Assessment:

Assessment:

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical/ Oral Exam: An Oral examination will be held based on the above syllabus.

Recommended Books:

1. Stuart J. Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach Second Edition" Pearson Education.
2. Elaine Rich and Kevin Knight ―Artificial Intelligence‖ Third Edition, Tata McGraw-Hill Education Pvt. Ltd., 2008.
3. Ivan Bratko "PROLOG Programming for Artificial Intelligence", Pearson Education,

   Third Edition.
4. A Beginner's Guide to Generative AI: An Introductory Path to Diffusion Models, ChatGPT, and LLMs

Term Work:

At least 10 experiments covering the entire syllabus of **PCL503** (Artificial intelligence Lab) should be set to have well predefined inference and conclusion. This must include **50%** Hardware and **50%** Simulation experiments. The experiments should be student centric and attempts should be made to make the experiments meaningful and interesting. Experiments must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Note:

Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
22751141	Semiconductor Device Physics	03	--	--	03	--	--	03
		Examination Scheme						
		IA1	IA2	Total	ESE	Exam duration (Hrs.)	Total	
		20	20	40	60	02	100	

Course Prerequisite:

- Engineering Physics, Electronic Devices and Circuit

Course Objectives:

1. Explain semiconductor crystal structures and carrier dynamics with relevance to material selection in devices.
2. Apply carrier statistics to understand doping and conductivity control in IC fabrication.
3. Relate carrier transport mechanisms to modern electronic and optoelectronic devices.
4. Interpret recombination and generation processes in solar cells and photodiodes.
5. Connect junction physics to capacitance effects in RF and high-frequency circuits.
6. Discuss advanced materials and their role in high-power and high-speed applications.

Course Outcomes:

After successful completion of the course, student will be able to:

1. Explain semiconductor crystal structures and carrier dynamics with relevance to material selection in devices.
2. Apply carrier statistics to understand doping and conductivity control in IC fabrication.
3. Relate carrier transport mechanisms to modern electronic and optoelectronic devices.
4. Interpret recombination and generation processes in solar cells and photodiodes.
5. Connect junction physics to capacitance effects in RF and high frequency circuits.
6. Discuss advanced materials and their role in high power and high speed applications.

Module No.	Unit No.	Topics	Hrs.
1.0		**Fundamentals of Semiconductor Materials**	**05**
	1.1	Crystal structure, bonding, energy bands, direct vs indirect bandgap: applications in LEDs (direct bandgap) and solar cells (indirect bandgap)	
2.0		**Carrier Statistics and Semiconductor Properties**	**07**
	2.1	**Carrier statistics:** Fermi level, intrinsic & extrinsic semiconductors, effective mass, applications in doping control for ICs, sensors, and MEMS devices.	
3.0		**Carrier Transport Mechanisms**	**07**
	3.1	**Carrier transport:** drift, diffusion, mobility, conductivity, applications in high speed transistors, diffusion in PN junctions, semiconductor sensors	
	3.2	**Classical Transport** Drift current: mobility and conductivity, Diffusion current and gradient-based transport, Einstein relation D/μ, Continuity equation (basic idea)	

	3.3	**Transport in Nanoscale Devices**: Velocity saturation, Ballistic transport, Scaling effects	
4.0		**Recombination and Generation Mechanisms**	**06**
	4.1	Recombination & generation: carrier lifetime, quasi-Fermi levels: applications in solar cell efficiency, photodiode response, LED performance	
5.0		**PN Junction Physics**	**06**
	5.1	Junction physics: depletion region, built in potential, capacitance effects, applications in RF varactors, high frequency circuits, voltage controlled oscillators	
6.0		**Advanced Semiconductor Devices and Materials**	**08**
	6.1	Advanced topics: high field effects, avalanche breakdown, hot carriers, emerging materials (GaN, SiC, nano devices), applications in power electronics, high frequency communication, nano electronics	
	6.2	MultiGate Structures, Nanowire Transistors, Quantum dots, Spintronics.	
Total			**39**

Internal Assessment (40-Marks):

Internal Assessment (IA) consists of two class tests of 20 marks each. IA-1 is to be conducted on approximately 40% of the syllabus and IA-2 will be based on remaining contents (approximately 40% syllabus but excluding contents covered in IA-I). Duration of each test shall be one hour.

End Semester Examination (60-Marks):

Weightage to each of the modules in end-semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

8. Question paper will comprise of **total 06** questions, each carrying **15 marks**.
9. **Question No: 01** will be **compulsory** and based on entire syllabus wherein 4 to 5 sub-questions will be asked.
10. Remaining questions will be mixed in nature and randomly selected from all the modules.
11. **Total 04 questions** need to be attempted.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
22751181	Semiconductor Device Physics Lab	--	02	--	--	01	--	01
		Examination Scheme						
		Term Work		PR / OR Exam		Total		
		25		25		50		

Course Objectives:

1. Develop practical skills in measuring and analyzing semiconductor properties such as resistivity, mobility, and conductivity.
2. Apply theoretical concepts (carrier dynamics, junction physics, recombination) through hands-on experiments and simulations.
3. Investigate device behavior in real-world applications like solar cells, photodiodes, and PN junctions.
4. Use simulations to explore advanced materials (GaN, SiC) and nanoscale devices (nanowire transistors, quantum dots).
5. Strengthen experimental methodology by performing systematic measurements, interpreting data, and validating semiconductor models.
6. Bridge theory and practice to enhance understanding of modern electronic and optoelectronic devices.

Course Outcomes:

After successful completion of the course, student will be able to:

1. Measure and analyze semiconductor properties such as resistivity, carrier type, and mobility using experimental methods (e.g., four-probe and Hall effect).
2. Evaluate device performance by studying I–V characteristics of solar cells, photodiodes, and PN junctions under different conditions.
3. Apply simulations to understand band structures, carrier distributions, and advanced materials like GaN, SiC, nanowires, and quantum dots.
4. Bridge theoretical knowledge with practical applications in modern semiconductor devices, optoelectronics, and nanoscale electronics.

Suggested List of Experiments:

Sr. No.	Title of Experiment	Hrs.
1.	Resistivity measurement of semiconductor samples (four probe method)	2
2.	Hall effect experiment: determination of carrier type and mobility	2
3.	Study of photoconductivity in semiconductors	2
4.	Temperature dependence of conductivity (activation energy)	2
5.	Capacitance–voltage characteristics of a PN junction	2
6.	I-V characteristics of solar cells under illumination	2
7.	Simulation of band structures and carrier distribution	2
8.	Observation of breakdown phenomena in semiconductor junctions	2
9.	Study of recombination lifetime using photodiode response	2

10.	Simulation of advanced materials (GaN, SiC)	2
11.	Resistivity measurement of semiconductor samples (four probe method)	2
12.	Hall effect experiment: determination of carrier type and mobility	2
13.	Nanowire Transistor Simulation: Analyze transport in nanoscale devices	2
14.	Quantum Dot Behavior (Simulation): Study discrete energy levels	2

Assessment:

Term Work: Term Work shall consist of at least 8 to 10 experiments. Teachers should refer to the suggested experiments and can design additional experiments to maintain better understanding and quality. Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical & Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Note:

Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
22751142	**Machine Learning**	L	T	P	L	T	P	Total
		3	--	2	3	--	1	4
		Examination Scheme						
			IA1	**IA2**	**ESE**		**Total**	
		Theory	20	20	60		100	

Pre-requisite Course Codes	PC304 Data Structure and Algorithms, VSEC202 Python Programming, PC 401 Math	
Course Outcomes	After the successful completion students should be able to	
	CO1	Comprehend basics of machine learning
	CO2	Build mathematical foundation for machine learning
	CO3	Understand various machine learning models
	CO4	Select suitable machine learning models for a given problem
	CO5	Build neural network based models
	CO6	Apply dimensionality reduction techniques

Module No.	Unit No.	Topics	Reference	Hrs.
Module 1	**1**	**Introduction to Machine Learning**		6 Hrs
	1.1	Introduction to Machine Learning, Issues in Machine Learning, Application of Machine Learning, Steps of developing a Machine Learning Application	1,4,6,8	
	1.2	Supervised and Unsupervised Learning: Concepts of Classification, Clustering and Prediction, Training, Testing and validation dataset, cross validation, overfitting and under fitting of model		
	1.3	Performance Measures: Measuring Quality of model- Confusion Matrix, Accuracy, Recall, Precision, Specificity, F1 Score, RMSE, Bias -Variance trade-off		
Module 2	**2**	**Mathematical Foundation for ML**		5 Hrs
	2.1	System of Linear equations, Norms, Inner products, Length of Vector, Distance between vectors, Orthogonal vectors	2,7	
	2.2	Symmetric Positive Definite Matrices, Determinant, Trace, Eigenvalues and vectors, Orthogonal Projections, Diagonalization, SVD and its applications		

Module 3	**3**	**Linear models**		
	3.1	The least-squares method, Multivariate Linear Regression, Regularised Regression, Using Least-Squares Regression for classification	4,7,8	7 Hrs
	3.2	Support Vector Machine Constrained Optimization, Optimal decision boundary, Quadratic Programming, SVM for linear and nonlinear classification, Basics of Kernel trick.		
Module 4	**4**	**Clustering Algorithms**		
	4.1	Cluster Analysis: Basic Concepts; Partitioning Methods: K-Means, K Medoids; Hierarchical Methods: Agglomerative, Divisive, BIRCH; Density-Based Methods: DBSCAN, Hebbian Learning rule	3,11,12,9	6 Hrs
	4.2	What are outliers? Types, Challenges; Outlier Detection Methods		
Module 5	**5**	**Classification models**		
	5.1	Evolution of Neural Networks, Biological Neuron, Artificial Neural Networks, NN architecture, McCulloch-Pitts Model, Designing a simple network, Non-separable patterns, Perceptron model with Bias. Activation functions, Binary, Bipolar, continuous, Ramp. Limitations of Perceptron, Perceptron Learning Rule. Delta Learning Rule (LMS-Widrow Hoff), Multilayer perceptron network. Adjusting weights of hidden layers. Error back propagation algorithm Logistic regression	4,7,10,11, 12,9	11 Hrs
	5.2	Basic Concepts; Classification methods: Decision Tree Induction: Attribute Selection: Gini Index, Tree pruning, Multiclass Classification, K-Nearest Neighbors, Naive Bayes Classifier, Random Forest		
	5.3	Introduction of Ensemble methods, Bagging, Boosting, AdaBoost and Random forest.		
Module 6	**6**	**Dimensionality Reduction Techniques**		
	6.1	Curse of Dimensionality.	2,7,4	4 Hrs
	6.2	Feature Selection and Feature Extraction		
	6.3	Dimensionality Reduction Techniques, Principal Component Analysis, Linear Discriminant Analysis		
			Total	**39**

Course Assessment:

Theory:

IA1: 20 Marks written examination for one hour
IA2: 20 Marks written examination for one hour

ESE: 60 Marks written examination for two hours

Recommended Books:

1. Nathalie Japkowicz & Mohak Shah, "Evaluating Learning Algorithms: A Classification Perspective", Cambridge.
4. Marc Peter Deisenroth, Aldo Faisal, Cheng Soon Ong, "Mathematics for machine learning"
5. Samir Roy and Chakraborty, "Introduction to soft computing", Pearson Edition.
6. Ethem Alpaydın, "Introduction to Machine Learning", MIT Press
7. Peter Flach, "Machine Learning", Cambridge University Press
8. Tom M. Mitchell, "Machine Learning", McGraw Hill
9. Kevin P. Murphy, "Machine Learning — A Probabilistic Perspective", MIT Press
10. Stephen Marsland, "Machine Learning an Algorithmic Perspective", CRC Press
11. Shai Shalev-Shwartz, Shai Ben-David, "Understanding Machine Learning", Cambridge University Press
12. Peter Harrington, "Machine Learning in Action", DreamTech Press
13. Han Kamber, Data Mining Concepts and Techniques‖, Morgan Kaufmann Publishers

Online References:

5. NPTEL: https://nptel.ac.in/courses/106106139
6. Supervised Machine Learning: Regression and Classification | Coursera
7. https://www.learndatasci.com/out/google-machine-learning-crash-course/

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
22751182	Machine learning Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
		Term work		Oral and Practical			Total	
		25		25			50	

Pre-requisite Course Codes	PC304 Data Structure and Algorithms, VSEC202 Python Programming, PC 401 Math	
Laboratory Objectives	1.	To understand the implementation of basic Machine Learning algorithms using Python.
	2	To apply classification, regression, clustering, and dimensionality reduction techniques on datasets.
	3.	To analyze the performance of Machine Learning models using suitable evaluation metrics.

	4.	To develop problem-solving skills for real-world Machine Learning applications.
Laboratory Outcomes	After the successful completion students should be able to	
	LO 1	Implement supervised and unsupervised Machine Learning algorithms
	LO 2	Analyze Machine Learning models using suitable performance metrics and validation techniques.
	LO 3	Apply mathematical foundations and linear models for Machine Learning problems.
	LO 4	Implement classification, clustering, and neural network techniques for data analysis.
	LO 5	Apply dimensionality reduction and feature extraction techniques on datasets.
	LO 6	Develop Machine Learning solutions for real-world engineering applications using appropriate tools and libraries.

Laboratory Experiments:

Sr. No.	Title of Experiment	Module	Reference
1	Study and implementation of basic Python libraries for Machine Learning: NumPy, Pandas, Matplotlib and Scikit-learn	1	8,10
2	Implementation of data preprocessing techniques including handling missing values, normalization and dataset splitting	1	4,6,8
3	Perform supervised learning using a simple classification dataset and evaluate model performance	1	1,4,6
4	Perform unsupervised learning using clustering techniques on a sample dataset	1	4,8,11
5	Implementation of performance evaluation metrics using Confusion Matrix, Accuracy, Precision, Recall, Specificity and F1 Score	1	1,5,9
6	Study of overfitting and underfitting using training and testing datasets with cross validation	1	4,5,9
7	Implementation of vector and matrix operations using NumPy	2	2,10
8	Program to compute norms, inner products and distances between vectors	2	2
9	Implementation of Eigenvalues, Eigenvectors and matrix diagonalization	2	2

10	Demonstration of Singular Value Decomposition (SVD) and its applications in data compression	2	2,8
11	Implementation of Simple and Multivariate Linear Regression using least squares method	3	4,6,8
12	Implementation and comparison of Linear Regression with Regularized Regression techniques (Ridge and Lasso)	3	7,9
13	Implementation of Logistic Regression for classification problems	3	4,7,8
14	Implementation of Support Vector Machine for linear and nonlinear classification using kernel functions	3	7,9
15	Implementation of K-Means clustering algorithm on real-world datasets	4	8,11
16	Implementation of K-Medoids clustering techniques	4	11
17	Implementation of Hierarchical clustering using Agglomerative methods	4	11
18	Implementation of DBSCAN clustering and analysis of density-based clusters	4	11
19	Detection and visualization of outliers using statistical and distance-based methods	4	11
20	Implementation of McCulloch-Pitts neuron and Perceptron learning algorithm	5	3,8
21	Study and implementation of various activation functions in Neural Networks	5	3,7
22	Implementation of Multilayer Perceptron using Backpropagation algorithm	5	3,8
23	Implementation of Decision Tree classifier and analysis using Gini Index	5	5,11
24	Implementation of K-Nearest Neighbors (KNN) classifier	5	4,11
25	Implementation of Naive Bayes classifier for categorical and numerical datasets	5	4,7
26	Implementation and comparison of ensemble learning methods: Bagging, AdaBoost and Random Forest	5	5,7,9
27	Implementation of feature selection techniques for dimensionality reduction	6	4,7
28	Implementation of Principal Component Analysis (PCA) for feature extraction and visualization	6	2,7
29	Implementation of Linear Discriminant Analysis (LDA) for classification and dimensionality reduction	6	2,7
30	Develop and evaluate a complete Machine Learning model pipeline for a real-world dataset	6	4,7,10

Laboratory Assessment:

Assessment:

Term Work: Term Work shall consist of at least 10 to 12 practical's based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical/ Oral Exam: An practical and Oral examination will be held based on the entire syllabus.

Term Work:

At least 10-12 experiments covering the entire syllabus should be set to have well predefined inference and conclusion. The experiments should be student centric and attempts should be made to make the experiments meaningful and interesting. Experiments must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Note:

Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
22751143	Data Base Management Systems	L	T	P	L	T	P	Total
		3	--	2	3	--	1	4
		Examination Scheme						
			IA1	IA2	ESE		Total	
		Theory	20	20	60		100	

Pre-requisite Course Codes		
Course Outcomes	After the successful completion students should be able to	
	CO1	Recognize the need of database management system
	CO2	Design ER and EER diagram for real life applications
	CO3	Construct relational models and write relational algebra queries.
	CO4	Formulate SQL queries.
	CO5	Apply the concept of normalization to relational database design.
	CO6	Describe the concept of transaction, concurrency and recovery

Module No.	Unit No.	Topics	Reference	Hrs.
Module 1	**1**	**Introduction Database Concepts**		4Hrs
	1	Introduction, Characteristics of databases, File system v/s Database system, View of Data: Data abstraction and data Independence, Data Models, Schemas and Instances, Three-Schema Architecture, Overall DBMS system architecture, Database Users and Administrator, Database Applications	1,2	
Module 2	**2**	**Entity–Relationship Data Model**		6Hrs
	2	The Entity-Relationship (ER) Model: Entity types: Weak and strong entity sets, Entity sets, Types of Attributes, Relationship constraints: Cardinality and Participation, Entity-Relationship Diagrams, Mapping ER model to a relational schema	1,2	

Module 3	**3**	**Relational Model and relational Algebra**	1,2	7 Hrs
	3.1	Introduction to the Relational Model, Codd's rules Relational schema and Concept of keys. Relational Algebra-operators, Relational Algebra Queries		
	3.2	Integrity constraints: key constraints, Domain Constraints, Referential integrity , check constraints		
Module 4	**4**	**Structured Query Language (SQL)**		8 Hrs
	4.1	Overview of SQL, Data Definition Commands, Data Manipulation commands, Data Control commands	1	
	4.2	Set and string operations, aggregate functions, group by, having, Views in SQL, Joins, Nested and Subqueries, Triggers.		
Module 5	**5**	**Relational-Database Design**		6Hrs
	5.	Concept of normalization, First Normal Form, Second Normal Form, Function Dependencies: Closure of Attribute sets, Algorithms for Decomposition: 3NF, Boyce-Codd Normal Form (BCNF).	1,3	
Module 6	**6**	**Transactions Management, Concurrency, and Recovery**		8Hrs
	6.1	Transaction concept, Transaction states, ACID properties, Transaction Control Commands, Concurrent Executions	1,2	
	6.2	Serializability:Conflict and View Concurrency Control: Lock-based, Timestamp-based protocols, Deadlock handling Recovery System: Log based recovery Database privacy and Security		
			Total	**39**

Course Assessment:

Theory:

IA1: 20 Marks written examination for one hour
IA2: 20 Marks written examination for one hour

ESE: 60 Marks written examination for two hours

Recommended Books:

[1] A. Silberschatz, H. F. Korth & S. Sudarshan, "Database System Concepts", McGraw Hill, 7thEdition 2019.
[2] R. Elmasri & S. B. Navathe, "Fundamentals of Database Systems", Addison Wesley, 7th Edition, 2016
[3] Raghu Ramakrishnan, "DatabaseManagement Systems", Mcgraw-Hill, 4thEdition, 2018
[4] C.J.Date, A.Kannan, S.Swamynathan," An Introduction to Database Systems", Pearson, Eighth Edition, 2006.

Online References:

[1] NPTEL courses on DBMS: Introduction to Database systems

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
22751183	Data Base Management Systems Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
		Term work		Orals			Total	
		25		25			50	

Pre-requisite Course Codes		
Laboratory Objectives	1.	To understand and design ER/EER models for real-world database applications.
	2.	To develop skills in mapping conceptual models to relational schemas.
	3.	To gain hands-on experience in SQL (DDL, DML, DCL, TCL) and query formulation.
	4.	To apply concepts of normalization, transactions, and concurrency control in database systems.
Laboratory Outcomes	After the successful completion students should be able to	
	LO1	Identify real-world problems and design appropriate ER/EER

		diagrams.
	LO2	Convert ER models into relational schema with proper keys and constraints.
	LO3	Create and manage databases using SQL commands.
	LO4	Write complex SQL queries using joins, nested queries, and aggregate functions.
	LO 5	Apply normalization techniques to design efficient and consistent databases.
	LO 6	Implement transaction management and concurrency control mechanisms in database systems.

Laboratory Experiments:

Sr. No.	Title of experiment	Hardware /Software	Module	Reference
1.	**Identify the case study and detailed statement of the problem. Design an Entity-Relationship(ER) / Extended Entity-Relationship (EER) Model.**	**Software**	**1**	
2.	**Mapping ER/EER to Relational schema model.**	**Software**	**2**	
3.	**Create a database using Data Definition Language (DDL) and apply integrity constraints for the specified System.**	**Software**	**2**	
4.	**Apply DML Commands for the specified system.**	**Software**	**3**	
5.	**To perform Simple queries, string manipulation operations and aggregate functions.**	**Software**	**3**	
6	**To perform Nested and Complex queries**	**Software**	**3**	
7	**To implement Views and Join operations.**	**Software**	**4**	
8.	**To perform DCL and TCL commands.**	**Software**	**4**	
9.	**To implement function and trigger.**	**Software**	**4**	
10.	**To demonstrate Database connectivity**	**Software**	**5**	

Laboratory Assessment:

Assessment:
Term Work: Term Work shall consist of at least 10 to 11 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.
Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)
Practical/ Oral Exam: An Oral examination will be held based on the above syllabus.

Recommended Books:

[1] Patrick Dalton,"Microsoft SQL Server Black Book".
[2] Patel J, "DBMS Lab Manual", eBookIt.com, 2012.

Term Work:

At least 10 experiments covering the entire syllabus of PEL 501 (**Data Base Management Systems** Lab) should be set to have well predefined inference and conclusion. The experiments should be student centric and attempts should be made to make the experiments meaningful and interesting. Experiments must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Note:

Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
22751144	Data Compression	L	T	P	L	T	P	Total
		3	--	1	3	--	1	4
		Examination Scheme						
		Theory	**IA1**	**IA2**	**ESE**		**Total**	
			20	20	60		100	
		Practical	**Term Work**		**Practical Exam**		**Total**	
			25		25		50	

Pre-requisite Course Codes	**PC301- Signals and Systems, PC304- Analysis of Algorithms, PC401 – Maths, PC403- Discrete Structures and Automata Theory,**	
Course Outcomes	After the successful completion students should be able to	
	CO1	Explain fundamentals of information theory, redundancy, and compression models.
	CO2	Apply statistical and dictionary-based lossless compression algorithms.
	CO3	Analyze transform and quantization techniques used in lossy compression.
	CO4	Explain image, audio, and video compression standards used in industry.
	CO5	Evaluate secure and efficient compression techniques for cloud, multimedia, and IoT applications.
	CO6	Implement and compare compression algorithms using modern software tools.

Module No.	Unit No.	Topics	Reference	Hrs.
Module 1	**1**	**Fundamentals of Data Compression and Information Theory**		7 Hrs
	1.1	Introduction to Data Compression, Need for Compression, Applications in Multimedia, Cloud, AI, IoT and Cyber Security	1, 2, 3	
	1.2	Lossless and Lossy Compression, Performance Measures: Compression Ratio, Redundancy, Entropy, Bit Rate and Distortion		
	1.3	Information Theory Fundamentals, Entropy,Mutual Information, Source Coding Theorem, Binary Symmetric Channels		
	1.4	Mathematical Models: Physical Models, Probability Models, Markov Models		
	1.5	Coding Concepts: Prefix Codes, Uniquely Decodable Codes, Kraft Inequality		
Module 2	**2**	**Statistical and Entropy-Based Compression Techniques**		8 Hrs
	2.1	Run Length Encoding (RLE), Shannon-Fano Coding	1, 2, 3, 4	
	2.2	Huffman Coding: Binary Huffman Coding, Adaptive Huffman Coding, Minimum Variance Huffman Coding, Extended Huffman code		
	2.3	Golomb Coding and Rice Coding		
	2.4	Arithmetic Coding: Encoding and Decoding Process, Binary Arithmetic Coding		
	2.5	Comparison of Huffman and Arithmetic Coding, Applications in Text and Image Compression		
Module 3	**3**	**Dictionary-Based and Predictive Compression Techniques**	1, 2, 3, 4	7 Hrs
	3.1	Dictionary-Based Compression: Static and Adaptive Dictionaries		
	3.2	LZ Family Algorithms: LZ77, LZ78, LZW		
	3.3	Burrows-Wheeler Transform (BWT) and Move-to-Front Coding		
	3.4	Prediction by Partial Matching (PPM), Context-Based Compression		
	3.5	Dynamic Markov Compression, Applications in GIF, PNG and Web Compression		
Module 4	**4**	**Image Compression and Modern Image Standards**		8 Hrs
	4.1	Fundamentals of Digital Images and Image Redundancies	1, 2, 3, 4	
	4.2	Transform Coding: Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT)		
	4.3	Scalar Quantization and Vector Quantization		
	4.4	JPEG Compression: Baseline JPEG and JPEG-LS		
	4.5	JPEG2000, WebP and HEIF Image Formats		
	4.6	Applications in Medical Imaging, Satellite Imaging and Mobile Platforms		
Module 5	**5**	**Audio and Video Compression Standards**		7 Hrs
	5.1	Basics of Digital Audio and Psychoacoustic Models	1, 2, 3, 4, 5	
	5.2	Audio Compression Techniques: MP3, AAC and FLAC Compression		
	5.3	Fundamentals of Digital Video, Spatial and Temporal Redundancy		
	5.4	Motion Estimation and Motion Compensation		
	5.5	Video Compression Standards: MPEG-1, MPEG-2, MPEG-4, H.264/AVC, H.265/HEVC and AV1		
	5.6	Applications in Video Streaming, OTT Platforms and Video Conferencing		

Module 6	**6**	**Secure Compression, Emerging Trends and Applications**		8 Hrs
	6.1	Compression and Encryption Relationship, Secure Compressed Data Transmission	2, 3, 4, 5, 6	
	6.2	Compression in Cloud Storage, IoT Devices and Edge Computing		
	6.3	Error Resilience and Compression in Cyber Security Applications		
	6.4	AI-Assisted Compression and Neural Data Compression Concepts		
	6.5	Green Computing and Energy-Efficient Compression		
	6.6	Case Studies: Google Brotli, Zstandard (Zstd), Secure Multimedia Streaming		
			Total	**45**

Course Assessment:

Theory:

IA1: 20 Marks written examination for one hour
IA2: 20 Marks written examination for one hour

ESE: 60 Marks written examination for two hours

Recommended Books:

[1] Khalid Sayood, *Introduction to Data Compression*, Morgan Kaufmann.
[2] David Salomon and Giovanni Motta, *Handbook of Data Compression*, Springe.
[3] Mark Nelson and Jean-Loup Gailly, *The Data Compression Book*, BPB Publication.
[4] Ian H. Witten, Alistair Moffat, Timothy Bell, *Managing Gigabytes*, Morgan Kaufmann.
[5] Rafael C. Gonzalez and Richard E. Woods, *Digital Image Processing*, Pearson.
[6] Yao Wang, Joemelakha and Alan Bovik, *Video Processing and Communications*, Pearson.

Online References:

1. NPTEL, "Data Compression", Available at: NPTEL Data Compression Course
2. MIT OpenCourseWare, "Information Theory and Data Compression", Available at: MIT OpenCourseWare - Information Theory and Data Compression
3. Stanford University, "Digital Signal Processing and Compression Concepts", Available at: Stanford Online Courses
4. Google Developers, "WebP Compression Technology", Available at: Google WebP Documentation
5. TensorFlow Compression Library, "Machine Learning Based Compression", Available at: TensorFlow Compression Library
6. Mozilla Developer Network (MDN), "Compression Techniques for Web Applications", Available at: MDN Compression Guide
7. IETF, "Brotli Compressed Data Format", Available at: IETF Brotli Specification

	Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
	22751184	Data Compression Lab	L	T	P	L	T	P	Total
			--	--	2	--	--	1	1
			Examination Scheme						
			Term work		Orals			Total	
			25		25			50	

Pre-requisite Course Codes	**ESL 102 BEEE Lab, BSL2012 Semiconductor Physics Lab**	
Laboratory Objectives	1.	To provide hands-on experience in implementing various data compression algorithms for text, image, audio, and video data
	2	To understand and analyze the performance of lossless and lossy compression techniques.
	3.	To introduce modern software tools and programming libraries used for multimedia compression applications.
	4.	To develop practical skills for implementing secure and efficient compression techniques used in cloud and multimedia systems.
Laboratory Outcomes	After the successful completion students should be able to	
	LO1	Implement basic lossless compression algorithms such as RLE, Huffman Coding, and Arithmetic Coding.
	LO2	Analyze and compare dictionary-based compression techniques including LZ77 and LZW algorithms.
	LO3	Implement image compression techniques using JPEG and transform coding methods.
	LO4	Evaluate audio and video compression standards using modern multimedia tools

	LO 5	Analyze compression efficiency using parameters such as compression ratio, bitrate, and redundancy.
	LO6	Develop applications related to secure and multimedia data compression using software tools and programming libraries.

Laboratory Experiments:

Sr. No.	Title of experiment	Hardware / Software	Module	Reference
1.	**Study of Compression Ratio and Performance Metrics for Different File Types**	**Software**	**1**	**1, 2**
2.	**Implementation of Run Length Encoding (RLE) for Text Compression**	**Software**	**2**	**1, 2**
3.	**Implementation of Shannon Fano and Huffman Coding for Text Compression**	**Software**	**2**	**1, 2, 3**
4.	**Comparative Analysis of Huffman and Arithmetic Coding Techniques**	**Software**	**2**	**1, 2, 3**
5.	**Implementation of Arithmetic Coding for Data Compression**	**Software**	**2**	**1, 2**
6	**Implementation of LZ77 Compression Algorithm**	**Software**	**3**	**1, 2**
7	**Implementation of LZ78 and LZW Compression Algorithm**	**Software**	**3**	**1, 2, 3**
8.	**Study and Implementation of Burrows-Wheeler Transform (BWT)**	**Software**	**3**	**1, 2**
9.	**JPEG Image Compression and Decompression using DCT**	**Software**	**4**	**1, 2, 5**
10.	**Comparative Analysis of JPEG and JPEG2000 Compression Standards**	**Software**	**4**	**1, 2, 5**
11.	**Implementation of Scalar and Vector Quantization Techniques**	**Software**	**4**	**1, 2**
12.	**Audio Compression using MP3 and AAC Formats**	**Software**	**5**	**1, 2, 6**
13	**Video Compression using MPEG and H.264 Standards**	**Software**	**5**	**1, 2, 6**
14	**Secure File Compression using Compression and Encryption Techniques**	**Software**	**6**	**2, 3**
15	**Mini Project: AI-Based Multimedia Compression and Performance Analysis**	**Software**	**6**	**3, 5, 6**

Laboratory Assessment:

Assessment:

Term Work: Term Work shall consist of at least 10 to 12 practicals based on the above list. Also, Term work Journal must include at least 2 assignments or one mini project/case study related to cybersecurity or cryptography applications.

Term Work Marks:

25 Marks (Total marks) =
15 Marks (Experiment)
5 Marks (Assignments/Mini Project)
5 Marks (Attendance)

Practical/ Oral Exam:

An Oral examination will be conducted based on the entire syllabus and laboratory experiments.

Recommended Software / Tools

1. MATLAB
2. Python (NumPy, OpenCV, Pillow)
3. FFmpeg
4. Wireshark
5. GZIP / ZIP Utilities
6. TensorFlow/PyTorch (for AI-based compression concepts)

Recommended Books:

[1] Khalid Sayood, *Introduction to Data Compression*, Morgan Kaufmann.
[2] David Salomon and Giovanni Motta, *Handbook of Data Compression*, Springe.
[3] Mark Nelson and Jean-Loup Gailly, *The Data Compression Book*, BPB Publication.
[4] Ian H. Witten, Alistair Moffat, Timothy Bell, *Managing Gigabytes*, Morgan Kaufmann.
[5] Rafael C. Gonzalez and Richard E. Woods, *Digital Image Processing*, Pearson.
[6] Yao Wang, Joemelakha and Alan Bovik, *Video Processing and Communications*, Pearson.

Term Work:

At least 10 experiments covering the entire syllabus of PEL 501 (Data Compression Lab) should be set to have well predefined inference and conclusion. This must include **50%** Hardware and **50%** Simulation experiments. The experiments should be student centric and attempts should be made to make the experiments meaningful and interesting. Experiments must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Note:

Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		3	--	--	3	--	--	3
22761131	**ASIC Design & Verification**	**Examination Scheme**						
			IA1	**IA2**	**ESE**		**Total**	
		Theory	20	20	60		100	

Pre-requisite Course Codes	**PCC2014 Digital Electronics** **PC 302 Electronic Devices** **PC 402 Analog Electronics** **PC 503 Semiconductor Devices and Characteristics**	
Course Objectives	1. To introduce the learner System Verilog concepts for verification. 2. To provide understanding of System Verilog and SVA for verification, and understand the improvements in verification efficiency. 3. To introduce the learner advanced verification features such as practical use of classes, randomization, checking and coverage. 4. To highlight the significance of verification in VLSI industry.	
Course Outcomes	After the successful completion students should be able to	
	CO1	Understand basics of Verilog Hardware Description Language and its programming
	CO2	Demonstrate an understanding of programmable devices and verification methodologies.
	CO3	Exploit new constructs in System Verilog.
	CO4	Understand the features of an object-oriented language: classes, object, varisbles
	CO5	Summarize ASIC verification techniques such as Randomization, assertions, coverage etc.
	CO6	Create layered test benches for digital designs in system Verilog.

Module No.	Unit No.	Topics	Reference	Hrs.
Module 1	**1**	**Introduction to Verilog HDL**	1,2	5Hrs
	1.1	Need for Hardware Description Languages (HDL), Overview of Verilog and its applications in digital system design, Difference between Verilog and conventional programming languages, Design flow using Verilog (Design → Simulation → Synthesis)		
	1.2	Module declaration and syntax, Input, Output, and In-out ports, Data types, wire, reg. Modeling Styles in Verilog: Gate-level modeling, Dataflow modeling, Behavioral modeling. Procedural Blocks: initial block, always block, Sensitivity list		
	1.3	Introduction to Testbench: Concept of simulation, writing a simple testbench, applying input stimulus, Observing outputs		
Module 2	**2**	**Programmable Devices and Verification Basics**	1,3	7Hrs
	2.1	**Programmable Devices**: Different types of Integrated Circuits-CPLD, FPGA, ASIC, SoC (System-on-Chip), SiP (System-in-Package), MCM (Multi-Chip Module), SoP (System-on-Package), Choices based on application and cost, Architecture of FPGA, CPLD (Xilinx and Altera family devices), Difference between ASIC, FPGA and CPLD, ASIC flow and overview of types of tools used in each stage of lifecycle		

	2.2	**Verification Basics**: Introduction, Verification Process, Verification Plan, Verification Methodology options, Basic Testbench Functionality, Directed Testing, Constrained-Random Stimulus, Functional Coverage, Testbench Components, Layered Testbench, Technology challenges test, Verification languages, Verification IP reuse, Verification approaches.		
Module 3	**3**	**Data types, Procedural statements, Connecting the Test bench and Design**	1,3	7Hrs
	3.1	Data Types: Built-in Data Types, Logic Data type, Fixed-Size Arrays (Packed and Unpacked arrays), Dynamic Arrays, Queues, associative array, array methods – Reduction, Locator & ordering, Creating New Types with typedef, Creating User-Defined Structures, Enumerated Types, Constants, Strings, Expression width.		
	3.2	**Procedural statements:** Procedural Statements, Tasks, Functions, and Void Functions, routine arguments, returning from a routine, Time values.		
	3.3	**Connecting the Test bench and Design:** Separating the test-bench and design, The Interface construct, Grouping Signals in an Interface using Modports, Creating Interface Monitor, Stimulus timing with Clocking Block, Test-bench design Race Condition, Program Block, Connecting it all together, Top level Scope, Program-Module interactions.		
Module 4	**4**	**Basic Object -Oriented Programming**	2,3	6Hrs
	4.1	OOP: Class, Creating new objects, Where to Define a Class, OOP Terminology, Understanding Dynamic objects, Object Deallocation, using objects, Static vs Global Variables, Class methods, Defining methods outside class, Scoping rules, Using one class inside another, Understanding Dynamic objects, Copying objects, public vs. local, Building a test-bench		
Module 5	**5**	**Randomization and Inter-process Communication**	2,3	7Hrs
	5.1	**Randomization:** Randomization in system Verilog, Constraint details, Solution probabilities, Controlling multiple constraint blocks, Valid constraints, In-line constraints, The pre-randomize and post-randomize functions, Random number functions, Constraints tips and techniques		
	5.2	**Threads and Inter-process Communication:** Working with threads, disabling threads, inter-process communication, Events, Semaphores, Mailboxes, building a test-bench with threads and IPC.		
Module 6	**6**	**System Verilog Assertions and Functional Cover**	2, 3	7Hrs
	6.1	**System Verilog Assertions**: Types of Assertions and examples, Immediate Assertions, Concurrent Assertions, SVA Property and Sequences, Implication (Overlapped & Non-Overlapped) Operator and Repetition Operator, System Verilog Assertion built-in methods ($rose, $fell, $stable, $past)		
	6.2	**Functional Coverage**: Coverage Types, Functional Coverage Strategies, Simple Functional Coverage Example, anatomy of a cover group, triggering a cover group, data sampling, cross coverage, generic cover groups, Coverage Options, Parameterized Cover Groups, Analysing Coverage Data, Measuring Coverage Statistics During Simulation.		
			Total	**39**

Course Assessment:

Theory:

IA1: 20 Marks written examination for one hour
IA2: 20 Marks written examination for one hour
ESE: 60 Marks written examination for two hours

Recommended Books:

[1]. Chris Spear, "System Verilog for Verification: A guide to learning the testbench language features", Springer, 3rd Edition.
[2]. J. Bhaskar "A Verilog HDL Primer" 3rd Edition Star Galaxy Publishing 2018.
[3]. Janick Bergeron, "Writing Testbenches Using System Verilog", Springer 2006.
[4]. Stuart Sutherland, Simon Davidmann, and Peter Flake, "System Verilog for Design: A guide to using system verilog for hardware design and modeling", Springer, 2nd Edition.
[5]. Ben Cohen, Srinivasan Venkataramanan, Ajeetha Kumari and Lisa Piper, "System Verilog Assertions Handbook", Vhdl Cohen Publishing, 3rd edition
[6]. S Prakash Rashinkar, Peter Paterson and Leena Singh, "System on Chip Verification Methodologies and Techniques", Kluwer Academic, 1st Edition.
[7]. System Verilog Language Reference manual
[8]. Samir Palnitkar, "Verilog HDL: A guide to Digital Design and Synthesis" second edition, Pearson – IEEE 1364-2001 compliant.
[9]. Spartan and Virtex family user manuals from Xilinx
[10]. Verilog Language Reference manual

Online References:

NPTEL courses on Introduction to ASIC design flow

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
22761171	**ASIC Design & Verification Lab**	**Examination Scheme**						
		Term work		**Practical & Orals**			**Total**	
		25		25			50	

Pre-requisite Course Codes		**PCC2014 Digital Electronics Lab**
Laboratory Objectives	1.	To introduce the learner System Verilog concepts for verification.
	2	To provide understanding of System Verilog and SVA for verification, and understand the improvements in verification efficiency.
	3.	To introduce the learner advanced verification features such as practical use of classes, randomization, checking and coverage.
	4.	To highlight the significance of verification in VLSI industry.
Laboratory Outcomes	After the successful completion students should be able to	
	LO1	Create test plan and test cases to verify any digital design.
	LO2	Apply the advanced verification techniques like Randomization on set of inputs.
	LO3	Create a transaction class and apply object -oriented programming for Verification.
	LO4	Carry out simulation of designs using System Verilog hardware verification language.
	LO5	Develop a complete Layered Test-bench for any digital design

Laboratory Experiments:

Sr. No.	Title of experiment	Hardware /Software	Module	Reference
1.	Write Verilog code for 4:1 MUX using all Verilog modeling styles and simulate the same.	**Software**	**1**	**1, 2, 3, 4**
2.	Write Verilog code and test-bench for D flip flop and 4 bit counter and simulate the same.	**Software**	**1**	**1, 2, 3, 4**
3.	Create a test plan and self-checking test-bench for the ALU.	**Software**	**2**	**1, 2, 3, 4**
4.	Create dynamic arrays, associative arrays, and queues using System Verilog.	**Software**	**2**	**1, 2, 3, 4**
5.	Write test bench using dynamic arrays, associative arrays with System Verilog to test a synchronous 8-bit x64K (512kBit) RAM.	**Software**	**2**	**1, 2, 3, 4**
6	Create an Interface for a Memory Design. Use Modport to assign direction to signal.	**Software**	**3**	**1, 2, 3, 4**
7	Create class and its objects and perform deep copy and shallow copy.	**Software**	**3**	**1, 2, 3, 4**
8.	Create an Interface for a Memory Design. (without modport)	**Software**	**3**	**1, 2, 3, 4**
9.	To understand and create Virtual interface and use it in a class.	**Software**	**4**	**1, 2, 3, 4**
10.	Given design specifications, draw waveform and write SVA expressions.	**Software**	**5**	**1, 2, 3, 4**
11.	To understand Constraint randomisation	**Software**	**5**	**1, 2, 3, 4**
12.	Create IPCs like events, mailbox and semaphores to interact between threads.	**Software**	**5**	**1, 2, 3, 4**
13.	Find coverage by writing cover groups for a design.	**Software**	**6**	**1, 2, 3, 4**
14.	Implementation of parallel processes using Fork Join/ join_any / join_none statement.	**Software**	**6**	**1, 2, 3, 4**
15.	Create a layered test-bench for a simple design like Adder or Memory module (Case study)	**Software**	**-**	**1, 2, 3, 4**

Recommended Books:

[1].J. Bhaskar “A Verilog HDL Primer” 3rd Edition Star Galaxy Publishing 2018.
[2].Janick Bergeron, “Writing Testbenches Using System Verilog”, Springer 2006.
[3].Verilog Language Reference manual
[4].Spartan and Virtex family user manuals from Xilinx.

Laboratory Assessment:

Assessment:

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.
Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)
Practical/ Oral Exam: An Oral examination will be held based on the above syllabus.

Term Work:

At least 10 experiments covering the entire syllabus of PCEL 602 (ASIC Design & Verification Lab) should be set to have well predefined inference and conclusion. The experiments should be student centric and attempts should be made to make the experiments meaningful and interesting. Experiments must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Note:

Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
22761132	Natural Language Processing	L	T	P	L	T	P	Total
		2	--	--	2	--	1	3
		Examination Scheme						
			IA1	IA2	ESE		Total	
		Theory	20	20	60		100	

Pre-requisite Course Codes	VSE 401 Creative Coding with python,	
Course Outcomes	After the successful completion students should be able to	
	CO1	Apply foundational NLP and deep learning concepts, along with basic text-processing techniques, to analyze language data and develop simple intelligent NLP application
	CO2	Apply finite-state techniques and N-gram models to analyze morphology and evaluate language models effectively.
	CO3	Analyze POS tagging methods and parsing techniques to interpret and construct accurate syntactic structures of natural language text.
	CO4	Interpret semantic and discourse techniques to understand text meaning and resolve references.
	CO5	Describe key LLM architectures and evaluation methods used in modern NLP systems.
	CO6	Identify major NLP applications and modern LLMs used for real-world language understanding tasks.

Module No.	Unit No.	Topics	Reference	Hrs.
Module 1	**1**	**Introduction to Deep Learning for NLP**		10 Hrs
	1.1	Biological neuron, Mc-Culloch Pitts Neuron, Perceptron Learning rule, Delta learning rule, Multilayer Perceptron: Linearly separable, linearly non-separable classes. Deep Networks: Fundamentals, Three Classes of Deep Learning, basic Terminologies of Deep Learning.	1	
	1.2	Training, Optimization and Regularization of Deep Neural Network Training Feed forward DNN Multi Layered Feed Forward Neural Network, Learning Factors, Activation functions, Loss functions.		
	1.3	CNN: Convolution Operation, Basic structure of a convolutional neural network: Padding, strides, pooling, fully connected layers, interleaving between layers. Training a convolutional network: Convolution/backpropagation as matrix multiplication.		
	1.4	Recurrent Neural Networks (RNN): Sequence Learning Problem, Unfolding Computational graphs, Recurrent Neural Network, Bidirectional RNN, Backpropagation Through Time (BTT), Vanishing and Exploding Gradients, Truncated BTT.		
Module 2	**2**	**Introduction to NLP and Text Processing**		5 Hrs
	2.1	What is Natural Language Processing (NLP)? History of NLP, Generic NLP System, Levels of NLP, Ambiguity and Layers of NLP. Challenges of NLP, Processing Indian Languages, Applications of NLP.	2,3	
	2.2	Basic Text Processing: Tokenization, Stopword Removal, Stemming and Lemmatization, Regular Expressions		
Module 3	**3**	**Word Level Analysis**		5 Hrs
	3.1	Survey of English Morphology, Inflectional Morphology, Derivational Morphology.	2,3	
	3.2	Morphological Models: Dictionary lookup, finite state morphology; Morphological parsing with FST (Finite State Transducer); Lexicon free FST Porter Stemmer algorithm		

	3.3	Language models- N-gram models and smoothing techniques: Laplace smoothing, Good-Turing Discounting, Evaluating language models- perplexity, cross-entropy		
Module 4	**4**	**Syntax Analysis**	2, 3, 4	8 Hrs
	4.1	Part-of-speech Tagging: Illustration of Ambiguity in POS, Table Look-up-based and Rule-based POS, Statistical POS Tagging: Hidden Markov Models (HMM) for POS tagging, Viterbi decoding algorithm; Chunking		
	4.2	Context-Free Grammars (CFG) and parse trees; Linguistics of Parsing		
	4.3	Algorithmics of Parsing, Constituency Parsing: Rule Based (Top-Down, Bottom-Up, CYK)		
	4.4	Statistical Parsing, Dependency Parsing and Neural Parsing		
Module 5	**5**	**Semantic and Discourse Processing**		6 Hrs
	5.1	Introduction, Meaning Representation; Lexical Semantics; Study of Various language dictionaries like WordNet, Lexical Relations	3, 5, 6	
	5.2	Word Embeddings: Word2Vec, CBOW, Skip-gram, GloVe		
	5.3	Word Sense Disambiguation (WSD) methods: Lesk algorithm Document representation: TF-IDF, Doc2Vec		
	5.4	Discourse Structure, Cohesion, Discourse Coherence & Structure, Reference resolution, Reference phenomena, Anaphora resolution using Hobbs algorithm		
Module 6	**6**	**Modern NLP with Transformers and Applications**		5 Hrs
	6.1	Introduction to Large Language Models (LLM), Fundamental components of the Transformer model	4, 5, 6	
	6.2	Transformer Architecture and Self-Attention Mechanism, Encoder–Decoder architecture, Introduction to pre-training and fine-tuning paradigms, Pretrained models (BERT, GPT, T5) and fine-tuning, Positional Encoding. Evaluation metrics (BLEU, ROUGE, F1)		
	6.3	Named Entity Recognition (NER), Question Answering System, Machine Translation.		
Total				**39**

Course Assessment:

Theory:
IA1: 20 Marks written examination for one hour
IA2: 20 Marks written examination for one hour
ESE: 60 Marks written examination for two hours

Recommended Books:

[1] **Charu C. Aggarwal**, Neural Networks and Deep Learning: A Textbook, 2nd Edition, Springer, 2023.
[2] Daniel Jurafsky, James H. and Martin, Speech and Language Processing, Third Edition, Prentice Hall, 2026.
[3] Christopher D.Manning and HinrichSchutze, Foundations of Statistical Natural Language Processing, MIT Press, 1999.
[4] Pushpak Bhattacharyya and Aditya Joshi, Natural Language Processing, Wiley India Pvt. Ltd., Edition: 2023
[5] Dr. Tanmoy Chakraborty, "Introduction to Large Language Models: Generative AI for Text", Wiley (Wiley India). December 2024.
[6] Palash Goyal, Sumit Pandey, Karan Jain. Deep Learning for Natural Language Processing-2018.
[7] Joseph Babcock, Raghav Bali, "Generative AI with Python and TensorFlow", Packt Publishing 2021.

Online References:

1. NPTEL Course"Natural Language Processing": https://onlinecourses.nptel.ac.in/noc23_cs45/preview
2. NPTEL Swayam "Natural Language Processing" : https://archive.nptel.ac.in/courses/106/106/106106211/

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
22761172	Natural Language Processing Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
		Term work		Orals			Total	
		25		25			50	

Pre-requisite Course Codes	VSE 401 Creative Coding with python	
Laboratory Objectives	1.	To understand deep learning models for classification and sequence learning problems.
	2	To familiarize with linguistic analysis through morphology, N-grams, and chunking.
	3.	To build statistical analysis for N-grams and parsing.
	4.	To understand semantic analysis and document similarity techniques
	5.	To learn NLP systems using standard classification techniques.
	6.	To understand large language models for understanding architectural variations.
Laboratory Outcomes	After the successful completion students should be able to	
	LO1	Implement and analyze deep learning models for classification and sequence learning problems.
	LO2	. Apply various text processing techniques for real-world NLP tasks.
	LO3	Analyze linguistic structures using morphological processing, N-grams, and chunking techniques
	LO4	Develop statistical and neural language models such as POS tagging, HMMs, and Pasers.
	LO 5	Use TF-IDF and cosine similarity to extract semantics and document distances.
	LO 6	Analyze and compare the performance, outputs, and capabilities of modern NLP models, including NER, BERT, and large language models.

Laboratory Experiments:

Sr. No.	Title of experiment	Hardware /Software	Module	Reference
1.	Study of Activation Functions used in Deep Learning. ii.Implementation of Feed Forward Neural Network using Python	Software	1	1
2.	Basic Text Preprocessing Techniques	Software	2	2,3
3.	Perform morphological analysis on input text to extract root words and morphemes, and generate new word forms using inflectional and derivational rules.	Software	2	2,3

4.	**Extraction of Email Addresses and Indian Mobile Numbers Using Regular Expressions**	**Software**	**2**	**3**
5.	**Perform chunking (shallow parsing) on text to extract phrases like noun phrases (NP) and verb phrases (VP)**	**Software**	**3**	**4**
6	**Study of Part-of-Speech Taggers and POS Tagging**	**Software**	**3**	**4**
7	**Perform Word Sense Disambiguation Using Lesk Algorithm**	**Software**	**4**	**4**
8.	**Word Embeddings Using Word2Vec and GloVe**	**Software**	**4**	**4,5**
9.	**Demonstrate TF-IDF and Document Similarity Analysis**	**Software**	**4**	**4,5**
10.	**Study of Transformer Architecture and Self-Attention Mechanism**	**Software**	**5**	**4,5**
11.	**Text Classification Using BERT Fine-Tuning**	**Software**	**5**	**4**
12.	**Named Entity Recognition (NER) on Text Data**	**Software**	**6**	**5**
13.	**Exploration of Modern NLP Models (GPT-4, Llama-3, Claude-3, Mistral, Gemini)**	**Software**	**6**	**5**

Laboratory Assessment:

Assessment:

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.
Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)
Practical/ Oral Exam: An Oral examination will be held based on the above syllabus.

Recommended Books:

[1] Charu C. Aggarwal, Neural Networks and Deep Learning: A Textbook, Second Edition, Springer, 2023.
[2] Daniel Jurafsky, James H. and Martin, Speech and Language Processing, Third Edition, Prentice Hall, 2026.
[3] Christopher D.Manning and HinrichSchutze, Foundations of Statistical Natural Language Processing, MIT Press, 1999.
[4] Pushpak Bhattacharyya and Aditya Joshi, Natural Language Processing, Wiley India Pvt. Ltd., Edition: 2023
[5] Dr. Tanmoy Chakraborty, "Introduction to Large Language Models: Generative AI for Text", Wiley (Wiley India). December 2024.

Term Work:

At least 10 experiments covering the entire syllabus of PCL 302 (Electronic Devices and circuits Lab) should be set to have well predefined inference and conclusion. This must include **50%** Hardware and **50%** Simulation experiments. The experiments should be student centric and attempts should be made to make the experiments meaningful and interesting. Experiments must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Note:
Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Course Code	Course Name	Teaching Scheme (Hrs/week)						Credits Assigned
		L	T	P	L	T	P	Total
22761133	Advanced Database Management Systems	3	--	--	3	--	--	3
		Examination Scheme						
			IA1	IA2	ESE	Total		
		Theory	20	20	60	100		

Pre-requisite Course Codes	PC 304 Analysis of Algorithm PC 402 Discrete Structure and Automata Theory PE 501 – Database Management Systems	
Course Outcomes	After the successful completion students should be able to	
	CO1	Explain query processing steps and apply optimization strategies to improve query execution in DBMS.
	CO2	Apply database security mechanisms DAC, MAC, and RBAC — and compare their access control models.
	CO3	Apply indexing structures (B-Trees, B+ Trees) and hashing techniques to organize and retrieve data efficiently
	CO4	Explain the architecture and classify parallelism types in parallel database systems
	CO5	Apply distributed database design principles including fragmentation and analyze query optimization in distributed environments.
	CO6	Classify and explain emerging database technologies such as NoSQL, graph, temporal, spatial, and cloud databases with their use cases.

Module No.	Unit No.	Topics	Reference	Hrs.
Module 1	**1**	**Query Processing and Optimization**	**1,2**	**7 Hrs**
	1.1	Query Processing Overview: Introduction, Query Processing in DBMS, Steps of Query Processing, Measures of Query Cost, Selection Operation, Sorting, Join Operation, Evaluation of Expressions.		
	1.2	Query Optimization: Overview and Goals of Query Optimization, Approaches of Query Optimization, Transformation of Relational Expressions, Estimating Statistics of Expression Results, Choice of Evaluation Plans.		
Module 2	**2**	**Indexing and Hashing**	**1,2**	**7 Hrs**
	2.1	Indexing Techniques: Basic Concepts of Indexing, Ordered Indices: Single-Level and Multi-Level Indexes, Indexed Sequential Access Method (ISAM), B-Tree and		

		B+ Tree Structure, Format of a Node, Search, Insert and Delete Operations in B+ Trees.		
	2.2	Hashing Techniques: Static and Dynamic Hashing, Multiple-Key Access and Bitmap Indexes, Comparison of Ordered Indexing and Hashing, Index Definition in SQL.		
Module 3	**3**	**Database Security and Advanced Access Protocols**	**1,3**	**5 Hrs**
	3.1	Database Security: Database Security Overview, Discretionary Access Control (DAC), Mandatory Access Control (MAC), Role-Based Access Control (RBAC), Database Auditing and Encryption Techniques.		
	3.2	Advanced Access Protocols: Remote Database Access Protocols, Introduction to Mobile Databases and their Characteristics.		
Module 4	**4**	**Parallel Databases**	**1,2**	**6 Hrs**
	4.1	Parallel Database Systems: Introduction to Parallel Databases, Architectures for Parallel Systems, I/O Parallelism and Data Partitioning Techniques, Interquery, Intraquery and Intraoperation Parallelism.		
	4.2	Parallel Database Operations: Parallelizing Database Operations — Bulk Loading, Scanning, Sorting and Joins, Design Challenges in Parallel Databases.		
Module 5	**5**	**Distributed Databases**	**2,3**	**8 Hrs**
	5.1	Introduction and Design Issues: Introduction to Distributed Database Systems, Distributed Data Processing, Advantages of Distributed Databases, Design Issues in Distributed DBMS, Distributed DBMS Architecture, Homogeneous and Heterogeneous Distributed DBMS.		
	5.2	Distributed Database Design and Query Processing: Top-Down Design Process, Fragmentation — Horizontal, Vertical and Mixed Fragmentation, Correctness Rules of Fragmentation, Replicated and Non-Replicated Allocation. Query Processing Overview, Objectives of Query Processing, Communication Cost, Layers of Query Processing, Query Optimization in Distributed Databases.		
Module 6	**6**	**Emerging Trends in Databases**	**2,3**	**6 Hrs**
	6.1	NoSQL and Graph Databases: Introduction to NoSQL Databases, Need of NoSQL, CAP Theorem, Types of NoSQL Databases, Introduction to MongoDB Architecture and CRUD Operations. Graph Databases: Introduction, Features, Transactions, Consistency, Availability, Querying, Case Study of Neo4j.		
	6.2	Advanced and Emerging Database Technologies: Temporal Databases — Concepts, Time Representation, Time Dimension, Incorporating Time in Relational Databases. Spatial Databases: Introduction, Data Types, Models, Operators and Queries. Introduction to Big Data, Introduction to Cloud Databases and DBaaS.		
Total	**39 Hrs**			

Course Assessment — Theory

IA1: 20 Marks written examination for one hour

IA2: 20 Marks written examination for one hour

ESE: 60 Marks written examination for two hours

Recommended Books

[1] A. Silberschatz, H. F. Korth & S. Sudarshan, "Database System Concepts", McGraw Hill, 7th Edition, 2019. — Modules 1, 2, 3, 4

[2] R. Elmasri & S. B. Navathe, "Fundamentals of Database Systems", Addison Wesley, 7th Edition, 2016. — Modules 1, 3, 5, 6 (Temporal & Spatial)

[3] Raghu Ramakrishnan & Johannes Gehrke, "Database Management Systems", McGraw-Hill, 3rd Edition, 2003. — Modules 1, 2, 3

[4] M. Tamer Ozsu & Patrick Valduriez, "Principles of Distributed Database Systems", Springer, 3rd Edition, 2011. — Module 5

[5] Kristina Chodorow, "MongoDB: The Definitive Guide", O'Reilly Media, 3rd Edition, 2019. — Module 6 (NoSQL/MongoDB)

[6] Ian Robinson, Jim Webber & Emil Eifrem, "Graph Databases: New Opportunities for Connected Data", O'Reilly Media, 2nd Edition, 2015. — Module 6 (Graph Databases/Neo4j)

Online References

[1] NPTEL courses on DBMS: https://nptel.ac.in

[2] MongoDB Documentation: https://www.mongodb.com/docs/

[3] Neo4j Documentation: https://neo4j.com/docs/

Laboratory Course

Course Code	Course Name	Teaching Scheme (Hrs/week)						Credits Assigned
		L	T	P	L	T	P	Total
22761173	Advanced Database Management Systems Lab	--	--	2	--	--	1	1
		Examination Scheme						
		Term Work			Orals			Total
		25			25			50

Pre-requisite Course Codes	PEL 501 – Database Management Systems Lab	
Laboratory Objectives	1. To analyze and implement query processing and optimization techniques. 2. To understand and apply database security models and access control mechanisms. 3. To implement B+ Tree indexing and hashing techniques for efficient data retrieval. 4. To explore parallel and distributed database operations. 5. To get hands-on experience with NoSQL databases (MongoDB) and graph databases (Neo4j).	
Laboratory Outcomes	*After the successful completion students should be able to*	
	LO1	Trace and compare query execution plans and apply optimization techniques to reduce query cost. [L3, L4]

	LO2	Apply and differentiate database security models — DAC, MAC, and RBAC — using SQL commands. [L3, L4]
	LO3	Apply B+ Tree indexing and hashing techniques to implement efficient data storage and retrieval. [L3]
	LO4	Explain data partitioning and apply distributed fragmentation strategies in database design. [L2, L3]
	LO5	Apply NoSQL (MongoDB) and graph database (Neo4j) operations for data management tasks. [L3]
	LO6	Explain temporal and spatial database concepts and apply them through structured queries. [L2, L3]

Laboratory Experiments

Sr. No.	Title of Experiment	Hardware/Software	Module	Reference
1.	Study and trace the steps of query processing: parsing, optimization, and execution using EXPLAIN / EXPLAIN ANALYZE in SQL.	Software	1	1, 2
2.	Apply relational algebra transformation rules for query optimization and evaluate query cost estimates.	Software	1	1, 2
3.	Implement B+ Tree structure: perform search, insert, and delete operations and trace node formats.	Software	2	1, 2
4.	Apply static and dynamic hashing techniques; compare performance with B+ Tree indexed access.	Software	2	1, 2
5.	Implement Discretionary Access Control (DAC) and Role-Based Access Control (RBAC) using SQL GRANT and REVOKE.	Software	3	1, 3
6.	Apply database auditing: log and monitor DML operations on sensitive tables using triggers and audit trails.	Software	3	1, 3
7.	Simulate I/O parallelism using data partitioning techniques: range partitioning, hash partitioning, and round-robin partitioning.	Software	4	1, 2
8.	Apply distributed database design: implement horizontal, vertical, and mixed fragmentation with allocation strategies.	Software	5	2, 3
9.	Apply distributed query processing: evaluate communication cost and layers of query optimization in distributed DBMS.	Software	5	2, 3
10.	Apply MongoDB CRUD operations, aggregation pipelines, and index creation on a document collection.	Software	6	2, 3
11.	Apply graph database operations using Neo4j: create nodes and relationships, and execute Cypher queries for graph traversal.	Software	6	2, 3
12.	Apply temporal database concepts: write queries using time dimensions and bi-temporal data management.	Software	6	2, 3

Laboratory Assessment

Term Work: Term Work shall consist of at least 10 to 12 practicals based on the above list. Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total) = 15 Marks (Experiments) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical/Oral Exam: An Oral examination will be held based on the above syllabus.

Recommended Books — Laboratory

[1] A. Silberschatz, H. F. Korth & S. Sudarshan, "Database System Concepts", McGraw Hill, 7th Edition, 2019. — Exps 1, 2, 3, 4, 7

[2] M. Tamer Ozsu & Patrick Valduriez, "Principles of Distributed Database Systems", Springer, 3rd Edition, 2011. — Exps 8, 9

[3] Kristina Chodorow, "MongoDB: The Definitive Guide", O'Reilly Media, 3rd Edition, 2019. — Exp 10

[4] Ian Robinson, Jim Webber & Emil Eifrem, "Graph Databases", O'Reilly Media, 2nd Edition, 2015. — Exp 11

[5] R. Elmasri & S. B. Navathe, "Fundamentals of Database Systems", Addison Wesley, 7th Edition, 2016. — Exps 5, 6, 12

Term Work

At least 10 experiments covering the entire syllabus of PEL 602 (Advanced Database Management Systems Lab) should be set with well-defined inference and conclusion. The experiments should be student-centric and attempts should be made to make them meaningful and interesting. Experiments must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Note

Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		3	--	2	3	--	1	4
22761134	Network Security	Examination Scheme						
			IA1	IA2	ESE		Total	
		Theory	20	20	60		100	

Pre-requisite Course Codes	Computer Network, Cloud Computing	
Course Outcomes	After the successful completion students should be able to	
	CO1	Explain fundamental concepts of network security and the security goals
	CO2	Apply cryptographic techniques for securing information and communication.
	CO3	Identify various network attacks, and evaluate their impact on systems and users.
	CO4	Interpret and analyze the working of secure communication protocols and mechanisms
	CO5	Implement and evaluate network security mechanisms applied to strengthen organizational defenses, and to reduce risk factors.
	CO6	Assess security challenges in cloud, wireless and web environments

Module No.	Unit No.	Topics	Reference	Hrs.
Module 1	**1**	**Introduction**		4Hrs
	1	Introduction, Security goals, CIA triad (Confidentiality, Integrity, Availability), Threats, vulnerabilities, attacks, Examples of passive vs active attacks, vulnerability analysis in network models, Security policies and risk assessment	1,2	
Module 2	**2**	**Cryptography Essentials**		6Hrs
	2	Symmetric encryption concepts (AES, DES), Asymmetric encryption (RSA), Hashing (SHA), digital signatures, Key Management, Key exchange (Diffie–Hellman), Certificates and PKI, VPN fundamentals	1,2	
Module 3	**3**	**Network Attacks & Defenses**	1,2	8Hrs
	3.1	Malwares: Virus, Worms, Trojans, Ransomware, DoS/DDoS attacks, Defense Mechanisms against DDoS attacks, Man-in-the-Middle (MITM), SYN flood attacks, Smurf attacks, ARP spoofing, DNS poisoning, Packet sniffing, Phishing & social engineering		
	3.2	Cyber crimes and Cyber Security: Classifications of cyber crimes, Botnets, Mobile phones and security Implications, Attacks on mobile devices – Viruses, Mishing, Vishing, Smishing		

Module 4	**4**	**Network Security Mechanisms**		7Hrs
	4.1	Authentication and access control: Password security, Multifactor authentication, Firewall – types and uses, Intrusion Detection/Prevention Systems (IDS/IPS), Access control Lists (ACLs), Network segmentation, Zero Trust concept, Honeypots and Honeynets	1	
	4.2	Cybercrimes: Legal perspective, Indian ITA 2000 and its amendments, Global perspective on cybercrimes		
Module 5	**5**	**Secure Network Protocols**		6Hrs
	5.1	Working and handshake overview of SSL/TLS, HTTPS vs HTTP, Secure email, Overview of S/MIME and PGP, Secure DNS, IPSec, SSL and VPN concepts	1,3	
	5.2	Security Monitoring: Log Analysis, Threat Intelligence		
Module 6	**6**	**Wireless & Web Security**		8Hrs
	6.1	Web vulnerabilities: SQL Injection, Cross Site scripting (XSS), Cross Site Request Forgery (CSRF), Wi-Fi security (WEP, WPA, WPA2, WPA3),	1,2	
	6.2	Secure Coding Practices, API security basics Introduction to Cloud security basics, risks, threats to cloud infrastructure, Cloud service provider risks Security in IoT		
			Total	**39**

Course Assessment:

Theory:

IA1: 20 Marks written examination for one hour
IA2: 20 Marks written examination for one hour

ESE: 60 Marks written examination for two hours

Recommended Books:

[1] William Stallings, Network Security Essentials: Applications and Standards, Pearson Education, 6th Edition, 2017.
[2] Atul Kahate, Cryptography and Network Security, McGraw Hill Education, 4th Edition, 2019.
[3] Behrouz A. Forouzan, Cryptography and Network Security, McGraw Hill Education, 1st Edition, 2007.
[4] Nina Godbole and Sunit Belapure, Cyber Security: Understanding Cyber Crimes, Computer Forensics and Legal Perspectives, Wiley India Pvt. Ltd., 1st Edition, 2011.
[5] Ronald L. Krutz and Russell Dean Vines, Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Wiley, 1st Edition, 2010.

Online References:

[1] NPTEL courses on Network Security

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
22761174	Network Security Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
		Term work		Orals			Total	
		25		25			50	

Pre-requisite Course Codes		
Laboratory Objectives	1.	To analyze Packets using Wireshark
	2.	To implement Basic Encryption & Hashing
	3.	Perform Password Security Experiments
	4.	Perform Vulnerability Scanning
Laboratory Outcomes	After the successful completion students should be able to	
	LO1	Use network monitoring and packet analysis tools to examine network communication and troubleshoot basic networking and security issues.
	LO2	Implement and test cryptographic techniques and secure key exchange using appropriate tools
	LO3	Analyze common network and web security attacks including ARP spoofing and SQL Injection, and identify suitable detection and mitigation mechanisms.
	LO4	Configure and evaluate security mechanisms

Laboratory Experiments:

Sr. No.	Title of experiment	Hardware /Software	Module	Reference
1.	Study of basic network configuration commands (ping, ipconfig, tracert, netstat)	Software	1	
2.	Packet capturing and analysis using Wireshark	Software	2	
3.	Implement AES and RSA encryption/decryption in Python/Java.	Software	2	
4.	Demonstrate Diffie–Hellman key exchange using a coding exercise	Software	3	
5.	Configure a firewall (iptables or pfSense) and/or set up Snort IDS to detect suspicious traffic.	Software	3	
6	Detection and Analysis of ARP Spoofing Attack using Wireshark	Software	3	

7	**Password strength analysis and authentication mechanisms**	**Software**	**4**	
8.	**Secure file transfer using SFTP/SSH**	**Software**	**4**	
9.	**Demonstrate SQL Injection and Detection**	**Software**	**4**	
10.	**Digital signature generation and verification**	**Software**	**5**	

Laboratory Assessment:

Assessment:
Term Work: Term Work shall consist of at least 8 practical based on the above list. Also, Term work Journal must include at least 2 assignments.
Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)
Practical/ Oral Exam: An Oral examination will be held based on the above syllabus.

Recommended Books:

Term Work:

At least 8 experiments covering the entire syllabus of PEL should be set to have well predefined inference and conclusion. The experiments should be student centric and attempts should be made to make the experiments meaningful and interesting. Experiments must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Note:

Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

<table>
<tr><th>Course Code</th><th>Course Name</th><th colspan="3">Teaching Scheme (Hrs/week)</th><th colspan="4">Credits Assigned</th></tr>
<tr><td rowspan="5">22761141</td><td rowspan="5">MEMS & Automation</td><td>L</td><td>T</td><td>P</td><td>L</td><td>T</td><td>P</td><td>Total</td></tr>
<tr><td>3</td><td>--</td><td>--</td><td>3</td><td>--</td><td>--</td><td>3</td></tr>
<tr><td colspan="7">Examination Scheme</td></tr>
<tr><td></td><td>IA1</td><td>IA2</td><td colspan="2">ESE</td><td colspan="2">Total</td></tr>
<tr><td>Theory</td><td>20</td><td>20</td><td colspan="2">60</td><td colspan="2">100</td></tr>
</table>

Pre-requisite Course Codes	PC 302 – Electronics Device PC 303 – Digital System Design PC 402 – Electronics Circuit & Design PC 403 – Physics of Semiconductor Devices
Course Objective	• To introduce semiconductor manufacturing environment, wafer preparation, and crystalline properties used in VLSI technology. • To explain semiconductor fabrication processes involved in integrated circuit manufacturing and emphasis on CMOS based integrated circuit fabrication flow, and layout design principles. • To provide knowledge of micromachining techniques and selecting suitable material for MEMS fabrication. • To familiarize students with modern semiconductor industry practices, for characterization of IC/MEMS, its sustainable packaging approaches, reliability, testing techniques and real-world engineering applications.
Course Outcomes: After successful completion of the course, student will be able to	
CO1	Differentiate IC and MEMS microfabrication technologies based on materials, scaling, structure, function, and applications.
CO2	Illustrate semiconductor and MEMS microfabrication processes and interpret the effect of fabrication parameters on process characteristics. .
CO3	Apply fabrication process sequences, layout mask concepts, and microfabrication technologies used in integrated microelectronic devices.
CO4	Describe MEMS layout mask concepts, material selection, and micromachining process flows for MEMS devices.
CO5	Illustrate the characteristics, packaging, and reliability aspects of semiconductor and MEMS devices based on industry-standard and sustainable engineering practices.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	**Introduction to Microfabrication**			**06**
	1.1	**Overview of microfabrication and its role in VLSI/MEMS**: Moore's Law, Scaling effects (electrical, mechanical, thermal, etc.), Historical evolution, applications in ICs, sensors, actuators, VLSI Technology Vs MEMS Technology, ICs Vs MEMS Devices	1,3	
	1.2	**Materials for microfabrication its Properties:** Materials like (but not limited to) Si, SiO2, SiN, SU8, PMMA, emerging materials like Graphene, Carbon Nano Tube	3	
2	**Substrate Preparation and Thin Film Deposition**			**06**
	2.1	**Substrate Preparation:** Crystal growth (Czochralski), wafer slicing/polishing	1,2	
	2.2	**Doping:** Thermal diffusion and Ion Implantation, annealing	1,2	
	2.3	**Thin film Deposition:** Evaporation, Sputtering and Chemical Vapor Deposition, Epitaxy, Thermal oxidation	1,2	
3	**Photolithography, and Patterning**			**06**
	3.1	**Introduction to Lithography:** Cleanroom classifications, contamination control, and safety, Photoreactive materials, photolithography process, mask preparation, advanced lithography types: Electron beam, Ion beam and X-ray lithography	1,2	
	3.2	**Etching:** Wet etching, Dry etching: Plasma/RIE, DRIE, ion milling	1,2	
4	**Process Integration**			**09**
	4.1	**Fabrication process sequence for:** integrated resistors, capacitors, and inductors; standard bipolar transistors and advanced bipolar devices; MOSFETs with emphasis on CMOS and memory devices; high-performance MESFETs and monolithic microwave integrated circuits (MMICs).	2	
	4.1	**CMOS IC Process Flow:** N well, P-well and Twin tub, Design rules, Layout of MOS based circuits (gates and combinational logic), Buried and Butting Contact	1,2	
	4.2	**Device Isolation and Metallization:** Junction and oxide isolation, LOCOS, trench isolation, Schottky contacts, Ohmic contacts, Metallization	1,2	
	4.4	MEMS fabrication using bulk, surface, and LIGA micromachining techniques with representative device examples.	2,3	
5	**Semiconductor and MEMS Device Characterization**			**06**
	5.1	**Semiconductor material characterization:** Resistivity, carrier concentration, mobility, sheet resistance, oxide thickness and crystal defects	1	
	5.2	**MEMS device characterization:** Device dimensions, piezoresistance, TCR, stiffness, adhesion, vibration and resonant frequency	3	
6	**IC and MEMS Packaging**			**06**
	6.1	**Introduction to semiconductor packaging:** Package functions, and package types, Package Types: DIP, QFP, BGA, CSP and Flip-chip packaging	4,5	

	6.2	**IC and MEMS packaging processes:** Die attach, wire bonding, wafer bonding, dicing and encapsulation	4,5	
	6.3	**Packaging materials and properties:** Molding compounds, bonding wires, solders, ceramics and heat spreaders	4,5	
	6.4	MEMS packaging requirements, reliability issues and packaging challenges	4,5	
			Total	**39**

Course Assessment:

Theory:

IA1: 20 Marks written examination for one hour
IA2: 20 Marks written examination for one hour

ESE: 60 Marks written examination for two hours

Text Books:

1. James D. Plummer, Michael D. Deal and Peter B. Griffin, "Silicon VLSI Technology", Pearson Education, First Indian Edition, 2000.
2. Simon M. Sze and Ming-Kwei Lee, "Semiconductor Devices: Physics and Technology", Wiley India, Third Edition, 2012.
3. James J. Allen, "Micro Electro Mechanical System Design", CRC Press, e-book Edition, 2005.
4. William J. Greig, "Integrated Circuit Packaging, Assembly and Interconnections", Springer, First Edition, 2007.
5. Andrea Chen and Randy Hsiao-Yu Lo, "Semiconductor Packaging: Materials, Interaction and Reliability", CRC Press.2012.

Reference Books:

1. Gary S. May and Simon M. Sze, "Fundamentals of Semiconductor Fabrication", Wiley India, First Edition, 2011
2. Tai-Ran Hsu, "MEMS and Microsystems: Design, Manufacture, and Applications", McGraw Hill Education, First Edition, 2017

Online References:

1. **https://nptel.ac.in/courses/117106093**
2. **https://nptel.ac.in/courses/117105082**

Term Work:

To strengthen the course, a compulsory visit to microfabrication laboratory at reputed institutes like IIT may be planned. Moreover, a mini case study or literature review on semiconductor manufacturing, integrated IC–MEMS systems, MEMS applications, packaging technologies, or device reliability may be included to enhance industry awareness and real-world understanding. Additionally, one lecture on sustainable semiconductor manufacturing and advanced packaging trends may be incorporated to address environmental and societal considerations in modern semiconductor industries.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
22761181	MEMS & Automation Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
			IA1	**IA2**	**Term Work**	Practical & Oral	**ESE Total**	
		Lab	--	--	25	--	25	

Pre-requisite Course Codes	PC 302 – Electronics Device PC 303 – Digital System Design PC 402 – Electronics Circuit & Design PC 403 – Physics of Semiconductor Devices
Course Objective	● To introduce semiconductor and MEMS microfabrication technologies, materials, scaling concepts, and process integration techniques used in integrated circuits and microsystems. ● To explain substrate preparation, doping, thin-film deposition, lithography, etching, and micromachining processes used in semiconductor and MEMS fabrication. ● To describe fabrication process flows, layout mask concepts, and microfabrication technologies used for passive and active integrated microelectronic devices. ● To explain MEMS fabrication using micromachining techniques, material selection, and representative MEMS device structures. ● To introduce semiconductor and MEMS device characterization methods, packaging technologies, reliability issues, and sustainable engineering practices relevant to microfabrication industries.
Course Outcomes: After successful completion of the course, student will be able to	
CO1	Simulate semiconductor and MEMS microfabrication processes and analyze the effect of process parameters on fabrication characteristics.
CO2	Perform characterization of semiconductor materials and micromachined structures to determine its important parameters and compare with theoretical parameters.
CO3	Design and verify layout masks and fabrication process flows for microelectronic devices using CAD/TCAD tools.
CO4	Analyze IC and MEMS packaging techniques and evaluate packaging effects on device performance, thermal behavior, and reliability using simulation and literature studies.

Suggested List of Experiments:

Sr. No.	Title
1	To simulate and analyze thermal oxidation of silicon using the Deal–Grove model and study the effect of process parameters on oxide growth characteristics.
2	To simulate dopant diffusion in semiconductor substrates and analyze the influence of diffusion parameters on impurity concentration profiles.
3	To determine electrical properties of semiconductor materials using virtual Hall Effect and Four Probe experimental setups.
4	**Simulation for CMOS IC Technology:** ● To design, simulate, and verify CMOS based combinational digital circuit layouts using industry-standard VLSI CAD tools. ● To design, simulate, and verify CMOS based sequential digital circuits using industry-standard VLSI CAD tools and evaluate their timing and layout characteristics. ● To design, simulate, and analyze CMOS arithmetic circuits such as adders and ALUs using industry-standard VLSI CAD tools.
5	**Simulation for Bipolar IC Technology:** ● To simulate and analyze semiconductor device characteristics such as PN junctions using industry-standard TCAD tools. ● To design, simulate, and evaluate MOS structures and MOSFET devices using TCAD tools and study their electrical characteristics. ● To simulate and analyze bipolar junction transistor structures using TCAD tools and evaluate their device performance parameters. ● To simulate and analyze semiconductor fabrication process steps such as oxidation, diffusion, and ion implantation using TCAD tools. ● To analyze short channel effects and scaling behavior in CMOS devices using TCAD simulation tools
6	**Simulation for Passive Components in IC Technology:** ● To design, simulate, and analyze integrated passive components such as resistors, capacitors, and interconnects using industry-standard VLSI CAD tools. ● To extract and evaluate parasitic resistance, capacitance, and inductance effects in VLSI interconnects and study their impact on circuit performance using simulation tools. ● To design and analyze MOS-based capacitors and diffusion/poly resistors and evaluate their electrical characteristics using industry-standard VLSI CAD tools.
7	To simulate MEMS fabrication process steps using industry-standard TCAD tools, design mask layouts, and analyze the resulting device structure.

8	To model and analyze the mechanical behavior of MEMS cantilever structures using the open source simulation tool (SUGAR)
9	To study and analyze IC and MEMS packaging techniques and evaluate the effect of packaging on device performance and reliability using FEM Multiphysics simulation tools.

(Course teachers can design their own experiments based on the prescribed syllabus)

Link for online resources:

1. **https://nanohub.org/**
2. **https://www.vlab.co.in/**
3. **www.microwind.com**

Note:

Suggested List of Experiments is indicative. However, flexibility lies with the individual course instructor designing and introducing new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students, and they can be motivated to think differently.

Term Work:

At least 8 experiments covering the entire syllabus must be given "Batch Wise". The experiments can be conducted with the help of a simulation tool, virtual lab and FEM tool. The teacher should refer to the suggested list of experiments and can design additional experiments to acquire practical design skills. The experiments should be student centric and attempts should be made to make experiments more meaningful, interesting and innovative.
Term work assessment must be based on the overall performance of the student with every experiment and assignments graded from time to time. The grades will be converted to marks as per "Credit and Grading System" manual and should be added and averaged. Based on the above scheme grading and term work assessment should be done.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
22761142	Signals and Image Processing	L	T	P	L	T	P	Total
		2	--	--	2	--	1	3
		Examination Scheme						
			IA1	IA2	ESE		Total	
		Theory	20	20	60		100	

Pre-requisite Course Codes	PC301: Signals & System (Mathematics III)	
Course Outcomes	After the successful completion students should be able to	
	CO1	Apply fundamental DSP principles to represent, analyze, and process discrete-time signals and systems
	CO2	Apply frequency-domain analysis techniques for efficient spectral analysis and processing of discrete-time signals.
	CO3	Apply image enhancement techniques in spatial and frequency domains to improve image quality.
	CO4	Analyze and apply image segmentation methods to extract meaningful regions from images.
	CO5	Apply morphological operations and image representation techniques for machine vision applications.
	CO6	Evaluate and apply appropriate image compression techniques to reduce image redundancy and optimize storage and transmission efficiency

Module No.	Unit No.	Topics	Reference	Hrs.
Module 1	1	**Digital Signal Processing Fundamentals**		7Hrs
	1.1	Introduction to Digital Signal Processing, Sampling and Reconstruction, Standard DT Signals, Concept of Digital Frequency, Representation of DT signal using Standard DT Signals,Operation on Signals(shifting, reversal, scaling, addition, multiplication), Classification of Discrete-Time Signals and Systems	1,2	
	1.2	Linear Convolution formulation for 1-D signal (without mathematical proof), Circular Convolution , Linear convolution using Circular Convolution. Auto and Cross Correlation,Concept of LTI system, Output of DT system using Time Domain Linear Convolution		
Module 2	2	**Discrete Fourier Transform and Fast Fourier Transform**		7Hrs
	2.1	Introduction to DFT, Properties of DFT without mathematical proof, Convolution of long sequences, Introduction to 2-D DFT.	1,2	
	2.2	Need of FFT, Radix-2 DIT-FFT algorithm, DIT-FFT Flow graph		

		for N=4 and 8, Inverse FFT algorithm.		
Module 3	**3**	**Fundamentals of Digital Image Processing**	3,4	8 Hrs
	3.1	**Fundamentals of Image Processing :** Introduction and Applications of Image Processing, Image Formation, Sampling and Quantization ,Basic Relationships between Pixels		
	3.2	**Intensity Transformations & Spatial Domain Enhancement :** Gray Level Transformations: Digital Negative, Log Transformation, Power-law Transformation, Contrast Stretching		
	3.3	**Histogram Processing:** Histogram Equalization, Histogram Matching		
	3.4	**Spatial Filtering & Frequency Domain Basics**: Smoothing Filters, Sharpening Filters, High-Boost Filters, Introduction to Frequency Domain Filtering (LPF, HPF – concept only)		
Module 4	**4**	**Image Segmentation**		6 Hrs
	4.1	**Thresholding Techniques** :Global and Adaptive Thresholding, Basics of Otsu's Method.	3,4	
	4.2	**Edge Detection:** Roberts, Prewitt, Sobel Operators, Laplacian and Canny edge detection.		
	4.3	**Region-Based Segmentation:** Region Growing ,Splitting and Merging, Watershed algorithm.		
Module 5	**5**	**Binary Image Processing and Image Representation**		7Hrs
	5.1	**Binary Image Processing:** Morphology**,** Erosion, Dilation, Opening, Closing, Hit-or-Miss Transformation, Boundary extraction , Hole filling, Thinning and Thickening	3, 4	
	5.2	**Image Representation:** Machine vision, Chain Codes, Shape Number, Polygon Approximation, Introduction to Texture, Co-occurrence matrix		
Module 6	**6**	**Image Compression**		4Hrs
	6.1	**Fundamentals:** Need of compression, Redundancy and Types, Compression Ratio, Compression Methods.	3,4	
	6.2	**Lossless Compression**: Run-Length Encoding, Huffman Coding, LZW Coding		
	6.3	**Lossy Compression:** Lossy Predictive Coding, Transform Coding, Improved Gray Scale Quantization.		
			Total	**39**

Course Assessment:

Theory:

IA1: 20 Marks written examination for one hour
IA2: 20 Marks written examination for one hour

ESE: 60 Marks written examination for two hours

Recommended Books:

[1] John G. Proakis and D.G. Manolakis Introduction to Digital signal processing Pearson Fourth edition, 2015

[2] A. NagoorKani Digital Signal Processing McGraw Hill Publications 2nd edition

[3] Rafel C. Gonzalez and Richard E. Woods, _Digital Image Processing‘, Pearson Education Asia, 3rd Edition, 2009.

[4] Anil K. Jain, _Fundamentals and Digital Image Processing‘, Prentice Hall of India Private Ltd, 3rd Edition**.**

[5] S. Jayaraman, E. Esakkirajan and T. Veerkumar, ―Digital Image Processing‖ TataMcGraw Hill Education Private Ltd, 2009

Online References:

1. Image Processing Tutorials: https://scikit-image.org/
2. MATLAB Image Processing Toolbox: https://www.mathworks.com/
3. NPTEL courses on Digital signal Processing https://onlinecourses.nptel.ac.in/noc19_ee50/course

Course Code	**Course Name**	**Teaching Scheme (Hrs/week)**			**Credits Assigned**			
22761182	**Signals and Image Processing Lab**	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
		Term work		**Orals**			**Total**	
		25		25			50	

Pre-requisite Course Codes	**PC301: Signals & System (Mathematics III)**	
Laboratory Objectives	1.	To develop a strong foundation in digital signal processing concepts including discrete-time signals, systems, sampling, reconstruction, signal operations, convolution, correlation, and LTI system analysis.
	2	To understand and apply frequency-domain analysis techniques such as DFT, FFT, and inverse FFT for efficient spectral analysis and processing of discrete-time signals.
	3.	To understand fundamental concepts and techniques of image segmentation and morphological operations
	4.	To analyze and implement lossless compression techniques such as Run-Length Encoding, Huffman Coding, and LZW Coding.

Laboratory Outcomes	After the successful completion students should be able to	
	LO1	To generate basic discrete-time signals such as unit impulse, unit step, ramp, exponential, and sinusoidal sequences using programming tools.
	LO2	To implement and compute linear, circular convolution, Discrete Fourier Transform and Inverse Discrete Fourier Transform for small sequences (4-point and 8-point).
	LO3	Develop programs for image enhancement in spatial and frequency domains.
	LO4	Implement segmentation algorithms for object detection and image analysis tasks.
	LO 5	Perform binary image processing using morphological operations for noise removal and shape enhancement
	LO6	Apply image compression techniques to an image to achieve efficient image storage.

Laboratory Experiments:

Sr. No.	Title of experiment (Suggested List of Experiments)	Hardware /Software	Module	Reference
1.	To Perform a program for generation of basic signals.	**Software**	**1**	**3**
2.	To perform linear and circular convolution of discrete time sequences.	**Software**	**1**	**3**
3.	To perform 4-point/8-point DFT and IDFT of the discrete time sequence and sketch the magnitude and phase spectrum.	**Software**	**2**	**3**
4.	Write a program to read and display images using a library (e.g., OpenCV/Matplotlib). Perform basic operations: cropping, resizing, and flipping images. To enhance image contrast using gray-level transformations and histogram equalization.	**Software**	**3**	**1,2**
5.	Write a program to implement spatial filtering techniques to an image for noise reduction and edge enhancement.	**Software**	**3**	**1,2**

6	Write a program to Implement edge detection algorithms: Sobel, Prewitt, and Canny.	**Software**	**4**	**1,2**
7	Write a program to Perform morphological operations: erosion, dilation, opening, and closing.	**Software**	**5**	**1,2**
8.	Write a program to Implement Fourier Transform to enhance images in the frequency domain.	**Software**	**2**	**1,2**
9.	Write a program to compress an image using a standard technique (e.g., Run-Length Encoding or JPEG).	**Software**	**6**	**1,2**
10.	Write a program to Perform color image processing: separate and manipulate RGB channels.	**Software**	**3**	**1,2**
11.	Design and implement any application of Image Processing (e.g., license plate detection or histogram-based image matching application etc.).	**Software**	**3, 4, 5, 6**	**1,2**

Laboratory Assessment:

Assessment:

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical/ Oral Exam: An Oral examination will be held based on the above syllabus.

Recommended Books:

[1] Digital Image Processing Using MATLAB, Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, Tata Mc Graw Hill Pvt. Ltd. Third Edition, 2011.

[2] Digital Image Processing and Analysis: Application with MATLAB and CVIP tools, SE Umbaugh, Taylor & Francis/CRC Press, 3rd Edition, 2018

[3] Digital Signal Processing Using MATLAB: A Problem Solving Companion by Vinay K. Ingle and John G. Proakis

Term Work:

At least 10 experiments covering the entire syllabus of PCL 302 (Electronic Devices and circuits Lab) should be set to have well predefined inference and conclusion. This must include **50%** Hardware and **50%** Simulation experiments. The experiments should be student centric and attempts should be made to make the experiments meaningful and interesting. Experiments must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Note:

Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
22761143	Cryptography	L	T	P	L	T	P	Total
		3	--	1	3	--	1	4
		Examination Scheme						
		Theory	IA1	IA2	ESE		Total	
			20	20	60		100	
		Practical	Term Work		Practical Exam		Total	
			25		25		50	

Pre-requisite Course Codes	PC401-Maths, PC502 - Computer Network	
Course Outcomes	After the successful completion students should be able to	
	CO1	Analyze security concepts and cryptographic fundamentals.
	CO2	Apply symmetric encryption techniques for secure communication.
	CO3	Analyze public key cryptographic algorithms and key exchange methods.
	CO4	Implement hashing, authentication, and digital signature techniques.
	CO5	Analyze secure communication protocols and PKI mechanisms.
	CO6	Evaluate emerging cryptographic technologies for cybersecurity applications.

Module No.	Unit No.	Topics	Reference	Hrs.
Module 1	**1**	**Introduction to Cryptography and Security Fundamentals**		7 Hrs
	1.1	Information Security Fundamentals, CIA Triad, Security Threats, Vulnerabilities and Attacks, Security Services and Security Mechanisms, Cryptography Terminology: Plaintext, Ciphertext, Encryption, Decryption, Keys	1, 2, 3	
	1.2	Classical Encryption Techniques: Caesar Cipher, Playfair Cipher, Hill Cipher, Vigenère Cipher, Transposition Cipher, Cryptanalysis Techniques		
	1.3	Steganography and Introduction to Modern Cryptography		
Module 2	**2**	**Symmetric Key Cryptography and Block Ciphers**		8 Hrs
	2.1	Symmetric Key Cryptography Principles, Stream and Block Ciphers, Feistel Structure, Confusion and Diffusion	1, 2, 3, 4	
	2.2	Data Encryption Standard (DES), Triple DES (3DES), Differential and Linear Cryptanalysis		
	2.3	Advanced Encryption Standard (AES): Structure, Key Expansion, Encryption and Decryption Process		
	2.4	Modes of Operation: ECB, CBC, CFB, OFB, CTR Modes, Introduction to Lightweight Cryptography		
Module 3	**3**	**Number Theory and Public Key Cryptography**	1, 2, 3, 4	8 Hrs
	3.1	Prime Numbers, Euclidean and Extended Euclidean Algorithms, Modular Arithmetic, Fermat's and Euler's Theorem, Chinese Remainder Theorem		
	3.2	Public Key Cryptography Concepts, RSA Algorithm, Diffie-Hellman Key Exchange, ElGamal Cryptosystem		
	3.3	Elliptic Curve Cryptography (ECC), Introduction to Post-Quantum Cryptography, Man-in-the-Middle Attack		
Module 4	**4**	**Hash Functions, Authentication and Digital Signatures**		7 Hrs
	4.1	Cryptographic Hash Functions, Properties of Hash Functions, MD5, SHA-1, SHA-2, SHA-3	1, 2, 3, 4	
	4.2	Message Authentication Codes (MAC), HMAC, CMAC		
	4.3	Digital Signatures, Digital Signature Standard (DSS), RSA-based Digital Signature, Authentication Protocols		
	4.4	Multi-Factor Authentication (MFA), Password Security and Salting Techniques		
Module 5	**5**	**Network Security and Public Key Infrastructure**		7 Hrs
	5.1	Public Key Infrastructure (PKI), X.509 Certificates, Certificate Authorities, Key Management and Distribution	1, 2, 4, 5	
	5.2	Kerberos Authentication Protocol, SSL and TLS Protocols		
	5.3	IP Security (IPSec), Virtual Private Networks (VPNs), Secure Email Systems: PGP and S/MIME		
	5.4	Firewalls and Intrusion Detection Systems (IDS)		
Module 6	**6**	**Emerging Trends and Applications in Cryptography**		8 Hrs
	6.1	Blockchain and Cryptocurrency Security, Cryptography in Cloud Computing	2, 3, 5, 6	
	6.2	Secure APIs, Zero Trust Security Model, Cryptography in IoT and Edge Devices		

	6.3	Quantum Computing Threats and Introduction to Post-Quantum Cryptography		
	6.4	AI in Cybersecurity, Secure Coding Practices, Case Studies on Security Breaches, Ethical and Legal Aspects of Cryptography		
			Total	**39**

Course Assessment:

Theory:

IA1: 20 Marks written examination for one hour
IA2: 20 Marks written examination for one hour

ESE: 60 Marks written examination for two hours

Recommended Books:

[1] William Stallings, "Cryptography and Network Security: Principles and Practice", Pearson Education.
[2] Behrouz A. Forouzan, "Cryptography and Network Security", McGraw Hill Education.
[3] Jonathan Katz and Yehuda Lindell, "Introduction to Modern Cryptography", CRC Press.
[4] Bruce Schneier, "Applied Cryptography", Wiley India.
[5] Wenbo Mao, "Modern Cryptography: Theory and Practice", Pearson Education.
[6] Mark Stamp, "Information Security: Principles and Practice", Wiley India.

Online References:

1. NPTEL – Cryptography and Network Security by IIT Kharagpur
2. Coursera – Applied Cryptography Specialization
3. MIT OpenCourseWare – Cryptography and Computer Security
4. Stanford Online – Computer and Network Security
5. Cybrary – Cryptography Fundamentals

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
22761183	Cryptography Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
		Term work		Orals			Total	
		25		25			50	

Pre-requisite Course Codes	**PCL403 Discrete Structures and Automata Theory Lab, VSE401 Creative Coding in Python, PCL502 Computer Network Lab**	
Laboratory Objectives	1.	To provide hands-on experience in implementing cryptographic algorithms and security techniques.
	2	To understand encryption, decryption, hashing, and authentication mechanisms through practical experiments
	3.	To analyze secure communication protocols and cryptographic security models
	4.	To introduce modern cryptographic tools and software used in cybersecurity applications.
	5.	To develop practical skills for designing secure systems and applications using cryptographic techniques.
Laboratory Outcomes	**After the successful completion students should be able to**	
	LO1	Implement classical and modern cryptographic algorithms for secure communication.
	LO2	Analyze symmetric and asymmetric encryption techniques using software tools.
	LO3	Implement hashing, authentication, and digital signature mechanisms.

	LO4	Analyze secure communication protocols such as SSL/TLS and IPSec.
	LO 5	Develop secure applications using cryptographic and cybersecurity tools.

Laboratory Experiments:

Sr. No.	Title of experiment	Hardware / Software	Module	Reference
1.	Implementation of Caesar Cipher and Monoalphabetic Cipher	Software	1	1, 2
2.	Implementation of Playfair and Vigenère vCipher Techniques	Software	1	1, 2
3.	Implementation of Hill Cipher and Transposition Cipher	Software	1	1, 3
4.	Study and Performance Analysis of DES Algorithm	Software	2	1, 2
5.	Implementation of Triple DES (3DES) Encryption and Decryption	Software	2	1, 2
6	AES Encryption and Decryption for Secure File Transfer	Software	2	1, 2, 3
7	Comparative Analysis of ECB, CBC, CFB, OFB, and CTR Modes of Operation	Software	2	1, 3
8.	Implementation of RSA Algorithm for Secure Communication	Software	3	1, 2, 3
9.	Implementation of Diffie-Hellman Key Exchange Algorithm	Software	3	1, 2
10.	Study and Implementation of Elliptic Curve Cryptography (ECC)	Software	3	2, 3
11.	Generation and Verification of Digital Signature using RSA/DSA	Software	4	1, 2, 3
12.	Implementation of SHA-256 and SHA-3 Hashing Algorithms	Software	4	1, 2
13	Development of Password Authentication System using Hashing and Salting	Software	4	1, 3
14	SSL/TLS Packet Analysis using Wireshark	Software	5	1, 2
15	Study of Firewall Configuration and Intrusion Detection System (IDS)	Hardware/ Software	5	2, 3
16	Mini Project: Blockchain-based Secure Transaction Demonstration	Software	6	3, 4
17	Study of Cryptography in Cloud Security using Secure API Communication	Software	6	2, 4

Laboratory Assessment:

Assessment:

Term Work: Term Work shall consist of at least 10 to 12 practicals based on the above list. Also, Term work Journal must include at least 2 assignments or one mini project/case study related to cybersecurity or cryptography applications.

Term Work Marks:

25 Marks (Total marks) =
15 Marks (Experiment)
5 Marks (Assignments/Mini Project)
5 Marks (Attendance)

Practical/ Oral Exam:

An Oral examination will be conducted based on the entire syllabus and laboratory experiments.

Recommended Software / Tools

1. Python with Cryptography Libraries
2. OpenSSL Toolkit
3. Wireshark Network Analyzer
4. Kali Linux Tools
5. CrypTool
6. GPG (GNU Privacy Guard)

Recommended Books:

[1] David A Bell, "Laboratory Manual for Electronic Devices and Circuits", 4th edition, PHI, [1] William Stallings, "Cryptography and Network Security: Principles and Practice", Pearson Education.
[2] Behrouz A. Forouzan, "Cryptography and Network Security", McGraw Hill Education.
[3] Bruce Schneier, "Applied Cryptography", Wiley India.
[4] Jonathan Katz and Yehuda Lindell, "Introduction to Modern Cryptography", CRC Press.

Term Work:

At least 10 experiments covering the entire syllabus of PEL 602 (Cryptography Lab) should be set to have well predefined inference and conclusion. This must include **50%** Hardware and **50%** Simulation experiments. The experiments should be student centric and attempts should be made to make the experiments meaningful and interesting. Experiments must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Note:

Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
22761144	Computer Communication Network	L	T	P	L	T	P	Total
		3	--	1	3	--	1	4
		Examination Scheme						
			IA1	**IA2**	**ESE**		**Total**	
		Theory	20	20	60		100	

Pre-requisite Course Codes	**PC 502-Computer Network**	
Course Outcomes	After successful completion students should be able to	
	CO1	Apply Internet architecture concepts for network performance analysis.
	CO2	Analyze application and transport layer protocols for reliable communication.
	CO3	Apply network layer concepts to analyze routing, forwarding, IP addressing, subnetting, and Software Defined Networking mechanisms.
	CO4	Apply LAN and data center networking concepts to demonstrate Ethernet operations, VLAN configuration, MAC addressing, and switching mechanisms.
	CO5	Analyze multimedia networking techniques for streaming, CDN, QoS, and real-time communication systems.
	CO6	Analyze wireless networks and security mechanisms for secure communication and mobility management.

Module No.	Unit No.	Topics	Reference	Hrs.
Module 1	**1**	**Internet Architecture and Network Performance Analysis**		7Hrs
	1.1	Internet structure: Network edge, access networks, core Packet switching vs circuit switching (comparative analysis), Delay analysis: Processing, queuing, transmission, propagation, Throughput and bottleneck link analysis,	1,2,3	
	1.2	Protocol layering and service models, Encapsulation, segmentation, and reassembly, End-to-End principle and protocol design issues, Introduction to performance evaluation metrics		
Module 2	**2**	**Application & Transport Layer Services**		7Hrs
	2.1	Application architectures: Client-server, Peer-to-Peer (P2P), hybrid-Web protocols: HTTP (persistent vs non-persistent, HTTP/2 overview) DNS: Hierarchy, caching, records	1,3,6	
	2.2	Email protocols: SMTP, POP3, IMAP, Socket programming concepts, Transport layer services: Multiplexing and demultiplexing, Reliable data transfer: Stop-and-wait, pipelined protocols		
Module 3	**3**	**Network Layer – Routing, Forwarding & SDN**	1,2, 4	7Hrs
	3.1	Router architecture: Input/output ports, switching fabric, forwarding vs routing, IP addressing: CIDR, subnetting, IPv6 basics		
	3.2	Routing algorithms: Distance vector and link state Routing protocols: RIP, OSPF, BGP, Network Address Translation (NAT)		
	3.3	Introduction to Software Defined Networking, Data plane vs control plane separation		
Module 4	**4**	**LANs & Data Center Networking**		4Hrs
	4.1	Ethernet: Frame structure and switching, VLAN basics, MAC addressing and ARP, Switching in LANs, Data Center Networking: Architecture and requirements, Traffic patterns and load balancing	2,3,5	

Module 5	**5**	**Multimedia Networking & Content Distribution**	1,4,5	6Hrs
	5.1	Multimedia networking applications, Streaming stored and live media ,DASH (Dynamic Adaptive Streaming over HTTP)		
	5.2	, Content Distribution Networks (CDN): Architecture and operation, Quality of Service (QoS) for multimedia: Delay, jitter, bandwidth requirements, Real-time transport: RTP/RTCP concepts, Internet telephony basics (VoIP)		
Module 6	**6**	**Wireless Networks & Network Security**	2,3,4	8Hrs
	6.1	Wireless networks: Wi-Fi (IEEE 802.11 architecture), Cellular networks: 3G/4G architecture basics, Mobility management: Handoff mechanisms, Wireless link characteristics and challenges		
	6.2	Network security fundamentals: Cryptography basics (symmetric/asymmetric) , Secure communication: SSL/TLS concepts, Authentication and integrity, Firewalls and intrusion detection systems, Security challenges in wireless networks		
			Total	**39**

Course Assessment:

Theory:

IA1: 20 Marks written examination for one hour
IA2: 20 Marks written examination for one hour

ESE: 60 Marks written examination for two hours

Recommended Books:

[1] James F. Kurose, Keith W. Ross, “Computer Networking: A Top-Down Approach”, Pearson Education, Latest Edition.
[2] Andrew S. Tanenbaum, David J. Wetherall, “Computer Networks”, Pearson Education, 5th Edition.
[3] Behrouz A. Forouzan, “Data Communications and Networking”, McGraw Hill Education, 5th Edition.
[4] William Stallings, “Data and Computer Communications”, Pearson Education, 10th Edition.
[5] Larry L. Peterson, Bruce S. Davie, “Computer Networks: A Systems Approach”, Morgan Kaufmann Publishers, Latest Edition.
[6] W. Richard Stevens, “TCP/IP Illustrated, Volume 1: The Protocols”, Addison-Wesley, Latest Edition.

Online References:

NPTEL courses on Computer Communication Network: Computer Networks and Internet Protocol by Prof. Soumya Kanti Ghosh Prof. Sandip Chakraborty

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
22761184	**Computer Communication Network Lab**	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
		Term work		**Orals**			**Total**	
		25		25			50	

Pre-requisite Course Codes	**PCL 502: Computer Network lab**	
Laboratory Objectives	**1**	To understand and analyze computer networking concepts through simulation and packet analysis tools.
	2	To implement application, transport, routing, and switching protocols using modern networking tools and programming techniques.
	3	To study network performance, secure communication, wireless networking, and Software Defined Networking concepts through practical experimentation.
	4	To develop hands-on skills in configuring, troubleshooting, and evaluating network architectures and communication mechanisms.
Laboratory Outcomes	After the successful completion students should be able to	
	LO1	Analyze network communication and performance metrics using packet analysis and simulation tools such as Wireshark and Packet Tracer.
	LO2	Implement client-server communication, socket programming, DNS, NAT, VLAN, and routing protocols in simulated network environments.

	LO3	Demonstrate Software Defined Networking, multimedia streaming, and wireless communication concepts using SDN and network simulation tools.
	LO4	Evaluate secure communication mechanisms, mobility management, and cellular/wireless network behavior through practical experimentation and traffic analysis.
	LO5	Interpret network performance and security characteristics by comparing protocol behaviours, analysing traffic patterns, and examining secure communication processes.

Laboratory Experiments:

Sr.NO	Title of experiment	Hardware /Software	Module	Reference
1.	To analyze the performance evaluation metrics in packet fragmentation using Wireshark	software	1	1, 3
2.	To perform Socket Programming using TCP and UDP in python	software	2	1, 4
3.	To implement Client -server architecture using HTTP/FTP using cisco packet tracer	Software	2	1, 2
4.	To create DNS resolution using cisco packet tracer	Software		1, 2
5.	To Configure OSPF and compare with RIP performance using Packet tracer/GNS3	Software	3	2, 3
6.	To Implement static and dynamic NAT and verify translation using Packet tracer	Software	3	2, 3
7.	To Create VLANs and demonstrate inter-VLAN communication using Packet Tracer	Software	4	2, 3

8.	To simulate client-server communication in SDN environment	Software	4	1, 2
9.	Study adaptive bitrate streaming using DASH.js + browser / YouTube stats	Software	4	1, 3
10.	To understand and analyze hand (handover) mechanisms in wirel networks using ns-3 or Mininet-WiFi.	Software	5	2, 3
11.	To analyze 4G cellular network traffic using Wireshark through a mobile hotspot connection.	Software	6	1, 3
12.	To understand secure communication mechanisms by analyzing encrypted network traffic using Wireshark (SSL/TLS Handshake Analysis)	Software	6	1, 4

Laboratory Assessment:

Assessment:

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical/ Oral Exam: An Oral examination will be held based on the above syllabus.

Recommended Books:

[1] J. F. Kurose and K. W. Ross, Computer Networking: A Top-Down Approach, 7th ed. Boston, MA, USA: Pearson, 2017.

[2] A. S. Tanenbaum and D. J. Wetherall, Computer Networks, 5th ed. Upper Saddle River, NJ, USA: Pearson, 2011.

[3] W. Stallings, Data and Computer Communications, 10th ed. Boston, MA, USA: Pearson, 2013.

[4] W. R. Stevens, TCP/IP Illustrated, Volume 1: The Protocols. Reading, MA, USA: Addison-Wesley, 1994.

Term Work:

At least 10 to 12 experiments covering the entire syllabus of Computer Communication Network Lab should be conducted with well-defined objectives, observations, inference, and conclusions. The practical should include a balanced combination of configuration-based,

programming-based, packet analysis, and simulation-based experiments using tools such as Cisco Packet Tracer, Wireshark, GNS3, Mininet, ns-3, and Python programming.

The experiments should be student-centric, focusing on hands-on implementation of networking concepts such as routing, switching, socket programming, network performance analysis, SDN, multimedia networking, wireless communication, and network security. Attempts should be made to design experiments that enhance analytical thinking, troubleshooting skills, and understanding of real-world communication systems.

Experiments must be graded periodically based on performance, understanding, implementation, observations, and viva. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be carried out according to this scheme.

The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral examination will be based on the entire syllabus.

Note:

The suggested list of experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative, and challenging experiments (limited to maximum 30% variation from the suggested list) within the scope of the curriculum. This will help students explore networking fundamentals and applications with greater clarity and encourage them to develop problem-solving and practical implementation skills in modern computer communication networks.

Vertical – 2

(MDM Courses offered by BoS -Electronics Engineering to other branches)

Course Code	Course Name	Teaching Scheme (Hours/week)			Credits Assigned			
		L	**P**	**T**	L	**P**	**T**	**Total**
2275211	Embedded Systems and RTOS	03	--	--	03	01	--	04
		Examination Scheme						
			IA1	IA2	ESE		Total	
		Theory	20	20	60		100	

Pre-requisite Course Codes	1. Digital Electronics 2. Basics of Microcontrollers	
After the successful completion of the course, students should be able to:		
Course Outcomes	CO1	Identify and describe various characteristic features and applications of embedded systems.
	CO2	To acquaint with fundamentals of embedded C programming.
	CO3	Analyse various processors in embedded systems and study ARM Cortex processor.
	CO4	To study various analog and digital interfaces used in embedded systems
	CO5	Compare GPOS and RTOS and investigate the concepts of RTOS.
	CO6	Based on life-cycle for embedded system design and test a system for different requirements, keeping oneself aware of ethics and environmental issues.

Module No.	Unit No.	Contents	Hrs.
1		**Introduction to Embedded Systems and Fundamentals of Embedded Programming**	**06**
	1.1	Definition, Characteristics, Embedded systems vs General Computing Systems, Classification, applications	
	1.2	Design metrics of Embedded system and challenges in optimization of metrics.	
	1.3	Embedded C: Need, data Types (bit, byte) ,Modifiers (static and volatile), bit operations, unsigned numbers representation, ISR (exception handling)	
2		**Embedded Processors**	**10**
	2.1	Features of Embedded cores- µC, ASIC, ASSP, SoC, FPGA, RISC and CISC cores. Types of memories.	
	2.2	Case Study: ARM Cortex-M3 Features, Architecture, Programmer's model, Special Registers, Operating Modes and States, MPU, Memory map and NVIC.	
	2.3	Low power: - Need and techniques. Case study of Low Power modes in Cortex-M3.	
	2.4	Compare A,R and M series	
	2.5	Hardware Features of ATMEGA 328P (Arduino Uno/Nano)	
3		**Interfacing Analog and Digital Devices**	**05**
	3.1	Interfacing various input (analog and digital) devices.	
	3.2	Interfacing various output (analog and digital) devices.	
	3.3	Signal Conditioning: Amplifiers, filters (LPF and notch filter)	
4		**Embedded Communication Interfaces**	**04**
		Comparative study of serial communication Interfaces :	
	4.1	4.1Wired: UART, SPI, I2C, CAN bus	
	4.2	4.2 Wireless: USB (v2.0), Bluetooth, Zig-Bee, RFID	
5		**Real Time Operating Systems**	**06**
	5.1	5.l Real-time Operating system:- Need of RTOS in Embedded system software and comparison with GPOS, Task, Task states, Multi-tasking, Task scheduling, and algorithms-Preemptive SJF, Round-Robin, Priority, Rate Monotonic Scheduling (graphical representation) , Earliest Deadline First. (Numerical on all scheduling techniques to estimate Turnaround time and schedulability).	
	5.2	Inter-process communication: Message queues, Mailbox, Event timers.	
	5.3	Task synchronization: Need, (issues:- Deadlock, Race condition, live Lock) solutions using Mutex, Semaphores. Shared data problem, Priority inversion and Work-around.	
6		**System Integration and Design**	08
	6.1	Embedded Product Design Life-Cycle (EDLC)	
	6.2	i) Specification requirements(choice of components), ii) Hardware architecture (Block Diagram) iii) Software architecture (FSM/flowchart) **iv)** Testing and Debugging Methodology **:**: Hardware testing tools, Emulator, Software Testing tools: simulator, debugger. White-Box and Black-Box testing.	
	6.3	Example applications: automatic vending machine, smart cards, agriculture, environment etc.	
		Total	**39**

Text Books:

1.Dr. K.V. K. K. Prasad, "Embedded Real Time System: Concepts, Design and Programming", Dreamtech, New Delhi, Edition 2014.

2.Rajkamal, "Embedded Systems: Architecture, Programming and Design", McGraw Hill Education (India) Private Limited, New Delhi, 2015, Edition 3rd.
3.Sriram Iyer, Pankaj Gupta," Embedded Real Time Systems Programming", Tata McGraw Hill Publishing Company ltd., 2003.
4. Joseph Yiu,"The Definitive guide to ARM CORTEX-M3 & CORTEX-M4 Processors", Elsevier, 2014, 3rd Edition.
5.www.freertos.org

Reference Books:

1.David Simon,"An Embedded Software Primer", Pearson, 2009.
2.Jonathan W. Valvano, "Embedded Microcomputer Systems – Real Time Interfacing", Publisher - Cengage Learning, 2012 Edition 3rd.
3.AndrewSloss, Domnic Symes, Chris Wright," ARM System Developers Guide Designing and Optimising System Software", Elsevier, 2004
4.FrankVahid, Tony Givargis,"Embedded System Design – A Unified Hardware/Software Introduction", John Wiley & Sons Inc., 2002.
5.Shibu K V, "Introduction to Embedded Systems", Tata McGraw Hill Education Private Limited, New Delhi, 2009.

Internal Assessment (20-Marks):

Internal Assessment (IA) consists of two class tests of 20 marks each. IA-1 is to be conducted on completion of approximately 40% of the syllabus, and IA-2 will be based on the remaining contents (approximately 40% syllabus, but excluding contents covered in IA-1). The duration of each test shall be one hour. The average of the two tests will be considered as the IA marks.

End Semester Examination (60-Marks):

Weightage to each of the modules in end-semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of **total 06 questions**, each **carrying 20 marks**.
2. **Question No: 01** will be **compulsory** and based on entire syllabus wherein 4 to 5 sub- questions will be asked.
3. Remaining questions will be mixed in nature and randomly selected from all the modules.
4. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5.**Total 04 questions** need to be solved.

Course Code	Course Name	Teaching Scheme (Hours/week)			Credits Assigned			
		L	P	T	L	P	T	Total
2275212	Embedded Systems and RTOS Lab	--	02	--	--	01	--	01
		Examination Scheme						
		Term Work		PR / OR Exam		Total		
		25		25		50		

Prerequisite: 1. Basics of Microcontroller programming
2. C programming

Lab Objectives: To design and write efficient code for single-tasking and multi-tasking embedded systems

Lab Outcomes:

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

- Interface various sensors and actuators to embedded cores.
- Write code using RTOS for multi-tasking Embedded systems
- Design applications using different embedded cores

Important Note:

1. Students must perform the experiments using Hardware.
2. Experiments must include a minimum of 3 experiments using Free RTOS

	Suggested List of Practicals /Tutorials	Ref.
1	Interfacing button (switch) controlled LEDs with any embedded core.	1,2,7
2	Interfacing of Temperature sensor with any embedded core.	1,2,7
3	Interfacing of LCD/ Seven segment display with any embedded core.	1,2,7
4	Interfacing of Ultrasonic/Humidity sensor with any embedded core.	1,2,4
5	Interfacing of a relay with any embedded core.	1,2,4
6	Interfacing of a DC motor (speed and Direction control) with any embedded core.	2,10
7	Interfacing of a stepper motor (to move by a particular angle) with any embedded core.	2,10,4
8	Implement power management in any embedded core of your choice	2,10
9	Implement the I2C communication to connect to any hardware	2,10
1	Porting of FreeRTOS to Arduino/STM32.	4
1	Write a Program to Create Multiple Tasks and understand the Multitasking capabilities of RTOS(FreeRTOS).	2
1	Write a Program to illustrate the Queue Management Features of FreeRTOS.	3
1	Write a Program to illustrate the Event Management Features of FreeRTOS.	4
1	Write a Program to illustrate the use of Binary and Counting Semaphore for Task Synchronisation using FreeRTOS.	5
1	Build a Multitasking Real-Time Applications using the above IPC Mechanisms (Message Queue, EventGroup, Semaphores) with FreeRTOS on Arduino/STM32.	6

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
2276211	Internet of Things (IoT)	L	T	P	L	T	P	Total
		3	--	2	2	--	2	4
		Examination Scheme						
			IA1	IA2	ESE		Total	
		Theory	20	20	60		100	

Pre-requisite Course Codes	(PC302) Electronic Devices, (MD401) Microprocessor and Microcontrollers, (MD501) Embedded System and RTOS (PC502) Computer Networks	
Course Outcomes	After successful completion students should be able to	
	CO1	Apply IoT system architecture concepts for real-world applications
	CO2	Integrate sensors and actuators with embedded IoT systems
	CO3	Analyse IoT communication models and wireless technologies.
	CO4	Apply concepts of Embedded and RTOS-based applications for IoT devices
	CO5	Analyze IoT data using cloud platforms and AI techniques
	CO6	Evaluate challenges in IoT Security and applications through case studies in IIoT, Healthcare IoT and Smart Grid systems

Module No.	Unit No.	Topics	Reference	Hrs.
Module 1	**1**	**IoT Architecture & Design**		6Hrs
	1.1	Introduction to IoT: Definition, Characteristics, Evolution, IoT vs M2M, IoT Architecture: 3-layer, 5-layer, Cloud-Fog-Edge architecture, End-to-End IoT System Architecture	1, 2, 3, 4, 5, 7	
	1.2	IoT Design Methodology: Requirement analysis, system design, prototyping, IoT Applications: Smart homes, smart cities, healthcare, agriculture		
Module 2	**2**	**Sensors, Actuators & Interfacing**		6Hrs
	2.1	Sensors: Types (Temperature, Humidity, Motion, Gas, Biomedical), Actuators: Relays, Motors, Solenoids, Sensor parameters, Interfacing challenges.	1, 2, 6, 7	
	2.2	Signal Conditioning basics (link to Analog Electronics) Interfacing Techniques: GPIO, ADC, DAC, PWM Communication Interfaces: I2C, SPI, UART		
Module 3	**3**	**Embedded Systems & RTOS for IoT**	2, 3, 4, 6	8 Hrs
	3.1	IoT Embedded Platforms: Arduino, ESP32, Raspberry Pi Embedded System Architecture for IoT nodes		
	3.2	Real-Time Systems: Concepts, Introduction to multitasking in IoT systems, scheduling, interrupts**,** RTOS basics: Tasks, queues, semaphores, Case Study: Free RTOS-based IoT system.		
Module 4	**4**	**IoT Communication & Networking**	1, 2, 3, 7	7 Hrs
	4.1	IoT Communication Models (D2D, D2C, D2G), Protocols: MQTT, CoAP, HTTP/REST, Protocol comparison		
	4.2	Wireless Technologies: WiFi, BLE, Zigbee, LoRa (overview)		
	4.3	IPv6 and addressing in IoT, Data transmission and reliability		
Module 5	**5**	**Cloud, Data Analytics & AI in IoT**		6Hrs

	5.1	IoT Cloud Platforms: AWS IoT / Azure IoT / Thing Speak Data Pipeline Flow	2, 5, 6, 7, 10	
	5.2	Data Storage: Structured vs unstructured, NoSQL basics		
	5.3	Data Visualization: Dashboards, Introduction to AI in IoT: Predictive analytics, anomaly detection, Edge vs Cloud processing		
Module 6	**6**	**IoT Security & Applications**		6Hrs
	6.1	Security Challenges in IoT, Ethics, Prototype to Reality.	3, 8, 9, 10	
	6.2	Authentication, Encryption basics, Privacy and data protection, Multi-layer IoT Security Architecture		
	6.3	Industrial IoT (IIoT) and Smart Manufacturing		
	6.4	Case Study-based IoT System Analysis: Healthcare IoT, Smart Grid		
Total				**39**

Course Assessment:

Theory:

IA1: 20 Marks written examination for one hour
IA2: 20 Marks written examination for one hour

ESE: 60 Marks written examination for two hours

Recommended Books:

1. Arshdeep Bahga, Vijay Madisetti, “Internet of Things: A Hands-on Approach”,Universities Press (India) Pvt. Ltd.,1st Edition, 2015
2. Raj Kamal, “Internet of Things”, McGraw Hill Education, 1st Edition, 2017.
3. Raj Kamal, “Internet of Things: Architecture and Design Principles”, McGraw Hill Education, 2nd Edition, 2022.
4. Adrian McEwen, Hakim Cassimally, “Designing the Internet of Things”, John Wiley & Sons, 1st Edition, 2013.
5. Samuel Greengard, “The Internet of Things”, The MIT Press, Revised and Updated Edition, 2021.
6. Raj Kamal, “Embedded Systems: SoC, IoT, AI and Real-Time Systems”, McGraw Hill Education, 4th Edition, 2020.
7. S. Misra, A. Mukherjee, and A. Roy, 2020. Introduction to IoT. Cambridge University Press.
8. S. Misra, C. Roy, and A. Mukherjee, 2020. *Introduction to Industrial Internet of Things and Industry 4.0.* CRC Press.
9. Ovidiu Vermesan, Peter Friess, “Internet of Things Applications - From Research and Innovation to Market Deployment”1st Edition ,First Published 2014,River Publishers DOIhttps://doi.org/10.1201/9781003338628,Pages364,eBook ISBN9781003338628
10. Ovidiu Vermesan, Joël Bacquet, “Internet of Things – The Call of the Edge-Everything Intelligent Everywhere” ISBN 9788770221962,392 Pages,Published August 31, 2020 by River Publishers.

Online References
NPTEL courses :

1. Prof. Sudip Misra, (IIT Kharagpur): Introduction To Internet Of Things By https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_cs37
2. Prof. Sudip Misra, (IIT Kharagpur): Introduction To Industry 4.0 And Industrial Internet Of Things https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_cs38

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
2276212	Internet of Things (IoT)	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
		Term work		Orals			Total	
		25		25			50	

Pre-requisite Course Codes	**(PC302) Electronic Devices, (MD401) Microprocessor and Microcontrollers, (MD501) Embedded System and RTOS**	
Laboratory Objectives	1.	To provide hands-on experience in interfacing sensors and actuators with embedded IoT platforms for real-time data acquisition and control.
	2	To enable students to design and implement IoT communication using standard protocols and wireless technologies
	3.	To develop skills in integrating IoT devices with cloud platforms for data storage, visualization, and basic analytics.
	4.	To design and implement end-to-end IoT applications by integrating hardware, embedded systems, networking, and software components
Laboratory Outcomes	After successful completion students should be able to	
	LO1	Interface sensors and acquire real-time data
	LO2	Implement communication using IoT protocols
	LO3	Develop embedded IoT applications
	LO4	Connect IoT devices to cloud platforms
	LO 5	Design and demonstrate mini IoT project

Laboratory Experiments:

Sr. No.	Title of Experiment	Hardware / Software	Module	Reference
1	Interfacing of Temperature and Humidity Sensor (DHT11/DHT22) with Arduino/ESP32 and display output	Hardware	2	1,2,3
2	Interfacing of Motion/IR Sensor and controlling an LED/Relay (Actuator Control)	Hardware	2	1,2,3
3	Study and implementation of communication interfaces (I2C/SPI) using sensors (OLED/RTC)	Hardware	2	3,5
4	Basic WiFi connectivity using ESP32 and sending sensor data to serial monitor/web server	Hardware/Software	4	3,5
5	Implementation of MQTT protocol using public broker (publish/subscribe model)	Software	4	3,4,5
6	HTTP/REST-based data transmission from IoT	Software	4	3,4,5

	device to cloud/server			
7	Cloud integration using ThingSpeak/Firebase for data logging and visualization	Software	5	3,4,5
8	RTOS-based multi-tasking IoT system using FreeRTOS (sensor + communication tasks)	Software	3	3,4,5
9	IoT Security implementation: Basic encryption/authentication for secure communication	Software	6	3,4,5
10	Mini Project: Design and implementation of IoT application (Smart Energy / Irrigation / Health Monitoring)	Hardware/Software	1–6	1,2,3,4,5
11	Case Study: Smart Home Automation System using IoT (Control of lights/fans via mobile/web interface with real-time monitoring)	Hardware/Software	1–6	1,2,3,4,5
12	Case Study: Smart Healthcare Monitoring System (Measurement of parameters like temperature/heart rate and cloud-based alert system)	Hardware/Software	1–6	1,2,3,4,5

Note:

Laboratory Assessment:
Assessment:

- Term Work: Term Work shall consist of at least 8 Practical's and 01 (group project) *, 01(Case Study) *(*-Suggested work by group of 3 to 5 students). Also, Term work Journal must include at least 2 assignments.
- Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)
- Practical/ Oral Exam: An Oral examination will be held based on the above syllabus.

Recommended Books:

1. David A. Bell, "Laboratory Manual for Electronic Devices and Circuits", Prentice Hall of India (PHI), 4th Edition, 2001.
2. Muhammad H. Rashid, "SPICE for Circuits and Electronics Using PSPICE", Prentice Hall of India (PHI), 2nd Edition, 1995.
3. Arshdeep Bahga, Vijay Madisetti, "Internet of Things: A Hands-on Approach", Universities Press (India) Pvt. Ltd., 1st Edition, 2015.
4. Simon Monk, "Programming Arduino: Getting Started with Sketches", McGraw Hill Education, 2nd Edition, 2016.
5. Dogan Ibrahim, "Internet of Things Projects with ESP32", Packt Publishing, 1st Edition, 2020.

Term Work:

At least 10 experiments covering the entire syllabus of MD 601 Internet of Things should be set to have well predefined inference and conclusion. The experiments should be student centric and attempts should be made to make the experiments meaningful and interesting. Experiments must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Note:

Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introducing new, innovative and challenging experiments, from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Vertical – 3

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
2275311	Industrial Automation	L	T	P	L	T	P	Total
		2	--	--	2	--	--	2
		Examination Scheme						
		Theory	IA1	IA2	ESE		Total	
			--	--	--		--	
		Practical	Term Work		Practical Exam		Total	
			50		--		50	

Pre-requisite Course Codes	(PC302) Electronic Devices, (PC501) Control System	
Course Outcomes	After successful completion students should be able to	
	CO1	Analyze industrial automation architecture and hierarchy.
	CO2	Identify, select, and justify appropriate sensors and actuators as per industry standards.
	CO3	Develop and implement basic PLC-based control logic for industrial processes
	CO4	Evaluate industrial communication protocols and SCADA systems
	CO5	Apply control system concepts such as PID control in energy-optimized industrial automation systems
	CO6	Analyze real-world industrial processes and propose automation solutions considering ethical practices, environmental sustainability, and Industry 4.0 technologies.

Module No.	Unit No.	Topics	Reference	Hrs.
Module 1	**1**	**Introduction to Industrial Automation**		6Hrs
	1.1	Concept of Automation, Types (Fixed, Programmable, Flexible)	1,2	
	1.2	Automation hierarchy (Field level, Control level, Supervisory level) Industrial Automation components overview		
	1.3	Industry 4.0 and smart manufacturing		
Module 2	**2**	**Sensors and Actuators in Automation**		6Hrs
	2.1	Industrial Sensors: Proximity, Temperature, Pressure, Level, Actuators: Relays, Solenoids, Motors (AC/DC, Stepper, Servo), Sensor characteristics: accuracy, resolution, hysteresis, Industrial interfacing (4–20 mA, 0–10V signals)	1,2	
	2.2	Signal conditioning, Selection criteria for sensors and actuators, safety standards (IEC, ISO basics),Fail-safe design concepts Industrial safety & sensor reliability		

Module 3	**3**	**Programmable Logic Controllers (PLC)**	1,2 6	8 Hrs
	3.1	Introduction to PLC: Architecture, working principle **,** PLC hardware: CPU, I/O modules, PLC I/O addressing basics		
	3.2	Programming languages: Ladder diagram, basics Timer, Counter, and basic logic implementation, Industrial case studies such as (but not limited to) Conveyor system, Tank filling system, Traffic light system		
Module 4	**4**	**SCADA, Industrial IoT & Data Systems**		7 Hrs
	4.1	Need for industrial communication, real-time requirements, latency and reliability		
	4.2	Industrial protocols: Modbus, Profibus, CAN, Industrial Ethernet (overview), IoT-based communication: MQTT, OPC-UA (introduction),	1,2 ,3,4	
	4.3	Industrial IoT (IIoT): Edge devices, gateways, cloud integration Protocol comparison table (Modbus vs CAN vs Ethernet) One data flow example (sensor → PLC → SCADA → cloud)		
	4.4	SCADA systems: Architecture, components, real-time monitoring, Data acquisition systems and Industrial Data Flow Architecture.		
Module 5	**5**	**Advanced Control Systems & Intelligent Automation**		6Hrs
	5.1	Open-loop and closed-loop control systems, PID control: Tuning methods and industrial significance, PID tuning concept (Ziegler-Nichols basic idea)	1.2,3, 4,5	
	5.2	Industrial control strategies: Adaptive and supervisory control (overview)		
	5.3	Distributed Control Systems (DCS): Architecture and applications, Introduction to AI/ML in industrial automation such as (but not limited to) predictive control, anomaly detection.		
Module 6	**6**	**Smart Manufacturing & Industrial Applications**		6Hrs
		● Automated assembly line ● Smart factory architecture ● Digital twins and cyber-physical systems ● Automation in manufacturing systems, power plant monitoring, Chemical Plant Automation, Smart Irrigation System,	1,2,3, 4,5,6	
			Total	**39**

Course Assessment:

Term Work:

To strengthen the course, a compulsory mini case study on automation failure or AI-based predictive maintenance can be included to highlight real-world relevance and ethical considerations. A small project or experiment, such as sensor-based data logging using a microcontroller/FPGA or a PLC automation demo, can improve practical exposure and industry connection.

Recommended Books:

1. Frank D. Petruzella, “Programmable Logic Controllers”, McGraw Hill Education, 5th Edition, 2016.

2. B. R. Mehta, Y. J. Reddy, “Industrial Process Automation Systems: Design and Implementation”, Elsevier, 1st Edition, 2014.

3. Krishna Kant, “Computer-Based Industrial Control”, PHI Learning, 2nd Edition, 2010.

4. Chanchal Dey, Sunit Kumar Sen, “Industrial Automation Technologies”, CRC Press / Taylor & Francis, 1st Edition, 2020.

5. K. S. Manoj, “Industrial Automation with SCADA: Concepts, Communications and Security”, Notion Press, 1st Edition, 2019.

6. Sanjay B. Katariya, “Industrial Automation Solutions for PLC, SCADA, Drive and Field Instruments”, Notion Press, 1st Edition, 2020.

Online References:

1. **https://onlinecourses.nptel.ac.in/noc22_me59/preview**
2. **https://nptel.ac.in/courses/108105063**

List of Experiments:

Sr. No.	Title of Experiment / Mini Project	Hardware / Software	Module	Reference
1	Simulation of Industrial Automation Hierarchy using Smart Factory Blocks	Draw.io, Factory I/O Community Edition	Module 1	1, 2
2	Virtual Study of Industrial Sensors and Actuators	Tinkercad Circuits	Module 2	1, 2
3	PLC Ladder Logic Simulation for Start-Stop Motor Control	OpenPLC Editor	Module 3	1, 6
4	Conveyor Belt Automation Simulation using Ladder Diagram	OpenPLC, Factory I/O Community Edition	Module 3	1, 2
5	Traffic Light Controller using PLC Simulation	OpenPLC	Module 3	1, 2
6	MQTT Communication Demo between Virtual Devices	Node-RED, Mosquitto MQTT	Module 4	3, 4
7	Mini SCADA Dashboard for Temperature Monitoring	Node-RED, ScadaBR	Module 4	4, 5
8	PID Control Simulation for DC Motor Speed Control	MATLAB Online Trial or Scilab	Module 5	2, 5
9	Predictive Maintenance using Sample Sensor Dataset	Python, Google Colab	Module 5	4, 5
10	Smart Irrigation Logic Simulation using Virtual Sensors	Tinkercad Circuits, Node-RED	Module 6	2, 4

General Instructions for Students:

Students are expected to perform the experiments/projects in self-learning mode using freely available open-source simulation tools and online resources. Before implementation, students should study the basic concepts related to the assigned module through lecture notes, tutorials, or reference videos. Each student should document the objective, procedure, simulation setup, observations, and conclusion with appropriate screenshots/results. The experiments are designed to be completed at home within approximately 2 hours and focus on conceptual understanding, simulation skills, and practical exposure to industrial automation technologies.

Vertical - 4

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
2276411	Mini Project - II	---	04	---	---	02	---	02

Course Code	Course Name	Theory					Term Work	Practical / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I + IAT-II					
2286411	Mini Project - II	---	---	---	---	---	50	---	50

Course Objectives:

Sr. No.	Course Objectives
1	To enable students to identify real-world problems through need-based surveys, literature review, and structured requirement analysis.
2	To develop skills in formulating clear problem statements and project objectives based on feasibility, innovation, and societal relevance.
3	To train students in designing and planning project execution using tools such as Gantt charts, PERT/CPM, and structured methodologies.
4	To provide hands-on experience in developing and implementing functional prototypes or models using appropriate engineering tools and domain-specific technologies.
5	To enhance teamwork, leadership, and project management skills through collaborative group work, progress tracking, and review presentations.
6	To cultivate professional competencies in documentation, technical communication, validation, and evaluation of project outcomes with sustainability and continuous learning focus.

Course Outcomes: On successful completion of the course, the learner will be able to:

Sr. No.	Course Outcomes	Cognitive Levels of Attainment as per Bloom's Taxonomy
1	Formulate a real-world problem by conducting need-based surveys and demonstrating professional responsibility in problem selection.	L2, L3, L4
2	Implement appropriate engineering methods to develop a functional solution while collaboratively exhibiting ethical teamwork behaviour.	L2, L3, L4, L5, L6
3	Demonstrate effective leadership or collaboration by actively coordinating project tasks and responding constructively to group dynamics.	L2, L3, L4
4	Validate experimental results through analytical techniques and justify findings with disciplined technical documentation.	L2, L3, L4, L5, L6

5	Evaluate the societal and environmental impact of the developed solution while applying sustainable engineering practices.	L3, L4, L5
6	Execute project activities using standard engineering tools while exhibiting commitment towards continuous self-directed learning.	L2, L3, L4, L5, L6

Guidelines for Mini Project - II:

1	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.
2	Interdisciplinary project is also allowed.
3	Students should do survey and identify needs, which shall be converted into problem statement for project in consultation with faculty supervisor/head of department/internal committee of faculties.
4	Students shall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of project.
5	A logbook to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
6	Faculty supervisor may give inputs to students during project activity; however, focus shall be on self-learning.
7	Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
8	Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
9	The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
10	With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the project.

Term Work:

The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of project to be evaluated on continuous basis, minimum two reviews in the semester.			
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 Term work marks shall be as below:			**Marks**
1	Marks awarded by guide/supervisor based on logbook		5
2	Marks awarded by review committee (Average of Review 1 & Review 2)		40
Project Review - 1			
1	Identification of Problem		4
2	Requirement analysis and Feasibility of the proposed work		4
3	Literature Review		4
4	Objectives of the proposed work		4
5	Methodology of the proposed work		4
	Total Marks		**20**
Project Review - 2			
	a	Planning of project work and team structure	4
	b	Design Methodology	4
	c	Conceptual and Technical Demonstration	4
	d	Presentation: Oral delivery, contact with audience, slides, timing	4
	e	Quality of answers	4
	Total Marks		**20**
	Quality of Project Report		**5**

Online References:

Sr. No.	URL
1	https://www.geeksforgeeks.org/project-idea-college-network/?ref=ml_lbp
2	https://www.simplilearn.com/tutorials/artificial-intelligence-tutorial/ai-project-ideas
3	https://roadmap.sh/backend/project-ideas
4	https://webflow.com/blog/website-ideas
5	https://gist.github.com/MWins/41c6fec2122dd47fdfaca31924647499
6	https://www.projectpro.io/article/artificial-intelligence-project-ideas/461
7	https://github.com/The-Cool-Coders/Project-Ideas-And-Resources
8	https://nevonprojects.com/project-ideas/software-project-ideas/
9	https://roadmap.sh/projects

Vertical – 5

IKS

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2275511	**Indian Knowledge System**	**2**	**2**	**--**	**2**	**2**	**--**	**2**

Course Code	Course Name	Theory					Term Work	Practical / Oral	Total
		Internal Assessment			End Semester Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I + IAT-II					
2285511	**Indian Knowledge System**	---	---	---	---	---	50	---	50

Rationale:

The proposed IKS modules contextualize core engineering principles across Computer, IT, EXTC, Electronics, and Electrical engineering—within scientifically analyzable Indian knowledge traditions. By mapping indigenous practices to modern technical frameworks, students critically examine foundational engineering concepts through interdisciplinary and systems-based perspectives. This approach strengthens conceptual understanding, promotes analytical reinterpretation of traditional knowledge using contemporary tools, and aligns engineering education with culturally rooted yet technically rigorous inquiry.

Prerequisite: -

Course Objectives:

1. Provide foundational knowledge of Indian acoustic practices.
2. To Understand ancient Indian use of renewable energy
3. Introduce Sanskrit grammar in simple language, with special attention to its rule-based structure.
4. Learners should be able to explain key contributions of ancient Indian mathematics in simple language
5. Understand how Indian traditions of logic, language, knowledge organization, design thinking, governance, sustainability, and wellbeing can support modern IT solutions.
6. Understand the basic structure of Sanskrit grammar and relate selected grammatical ideas to computational modules used in information technology.

Course Outcomes:

On successful completion of the course learner will be able to:

1. Analyze traditional Indian acoustic practices and interpret their relevance to frequency analysis.
2. Apply the traditional knowledge to modern energy solutions and sustainable engineering. 3. Apply Indian Knowledge Systems in linguistics, Sanskrit-based NLP, traditional number systems, measurement practices, and ancient rainfall prediction techniques using calendars, nakshatras, and natural indicators.
4. Apply basic modular arithmetic, pattern recognition, and place-value ideas to simple IT examples such as coding, data representation, and checksums.
5. Apply basic concepts of Indian Knowledge Systems such as logic, language, knowledge organization, ethics, sustainability, and responsible decision-making to design simple technology-based solutions like apps, chatbots, databases, or awareness tools.
6. Applybasic Sanskrit grammar concepts and Pāṇinian rule-based principles to understand formal grammar, algorithms, and simple computational language processing applications in IT.

DETAILED SYLLABUS:

Sr. No	Name of Module	Detailed Content	Hours	CO Mapping
0	**Prerequisite**	-	**-**	**-**
I	**Acoustic Science in Vedic Chanting and Indian Music**	I.1 Concept of Nāda (Sound) and Shruti • Physical interpretation: frequency, pitch, harmonic content • Shruti system (22 microtones) and frequency discrimination I.2 Resonance and Architectural Acoustics • Temple architecture and echo control • Natural acoustic amplification • Relation to reverberation time and standing waves I.3 Structured Sound Encoding in Vedic Recitation • Pada, Krama, Ghana patha recitation methods • Built-in redundancy → error detection and correction • Parallel to digital communication redundancy schemes **Self-Study:** Study of sounds and analysis in time and frequency domains.	**5**	**CO1**

II	**Traditio**	1. Introduction to IKS in renewable energy 2. Ancient Indian use of renewable energy a. Solar Energy: Solar Architecture, Solar Heating Systems b. Wind Energy: Ancient Windmills, Wind-Powered Water Lifting c. Water (Hydro) Energy: Ancient Watermills, Irrigation Systems d. Bioenergy: Biomass Fuel, Bioenergy Production 3. Integration of ancient Traditional knowledge of renewable energy with Modern Technologies. **Students shall study the following to understand the use of ancient technologies in Renewable Energy:** • Gujarat Windmills • Watermills in the Indus Valley • Konark Sun Temple	**5**	**CO2**

III		Linguistics: ● Components of language ● Panini's work on Sanskrit grammar ● Role of Sanskrit in Natural Language Processing Number System and Units of Measurement ● Number system in India- Historical Evidence ● Decimal System ● Unique Approaches to represent Numbers-Katapayadi System ● Pingala and the Binary System Ancient Indian techniques for predicting Rainfall ● Introduction ● Elements of the Indian Calendar ● Panchang and Nakshtras ● Non-bio indicators and Bio indicators **Self-Learning:** ● An Ecosystem for Sanskrit Language Processing ● Salient Features of the Indian Numeral System ● Salient Features of the Indian Numeral System ● Measurement for Time Distance and Weight ● Measurement of Time- An Illustration from Purana	**5**	**CO3**
IV	**Mathematics Foundations in Ancient India and Its Relevance to Information Technology**	4.1: Historical context and number ideas: Indian knowledge systems, the development of numeration, zero as placeholder and number, decimal place value. 4.2: Major contributors and procedural mathematics: Aryabhata, Brahmagupta, Bhaskara II, and examples of rule-based or sutra-like calculation methods in plain language. 4.3: Algorithmic thinking and computation: Historical mathematical procedures connect to algorithms, flowcharts, decomposition, and computational logic. 4.4: Modular arithmetic, binary-style ideas, and data representation: Clock arithmetic, remainders, cyclic reasoning, two-state representation, bits, bytes, and simple binary conversion.	**5**	**CO4**

		4.5: Relevance to IT and synthesis: Coding, checksums/parity, simple cryptography idea, data representation, and how ancient mathematical thinking supports modern IT problem-solving. **Self-Learning Topics and Activities**: ● Zero and place value in daily life ● Algorithmic thinking ● Modular arithmetic ● Binary representation .		
V	**Indian Logic and its applications in Information Technology**	5.1: Introduction to IKS and its relevance to contemporary technology. 5.2: Indian logic, language, and computation with simple examples. 5.3: Knowledge organization, data, and decision-making. 5.4: Ethics, society, sustainability, and responsible digital systems. 5.5 Mini activity where students design a small app, chatbot, database, or awareness tool using one IKS principle. **Self-Learning Topics and Activities**: •Basic ideas of Nyaya logic: observation, inference, debate, and evidence. •Introduction to Paninian grammar and why structured language matters in NLP. •Traditional knowledge classification and its connection with databases and knowledge graphs. •Technology for Indian languages, heritage preservation, digital museums, and public services. •Design thinking activity: identify a local problem and propose an IKS-inspired IT solution.	**5**	**CO5**
VI	**Sanskrit Grammar and Computational Modules**	6.1: Introduction to Indian Knowledge Systems, Sanskrit as structured language, and relevance to IT. 6.2: Basic Sanskrit grammar concepts: sounds, words, roots, suffixes, sandhi, and sentence structure. 6.3: Pāṇinian grammar as a rule-based system; relation with algorithms and formal grammar. 6.4: Computational modules: tokenization, morphology, parsing, language rules, and NLP examples. 6.5: Demonstration of Sanskrit digital tools, reflection activity, and discussion on interdisciplinary applications. **Self-Learning Topics and Activities**: ● Basic Sanskrit alphabet and sound classification. ● Simple sandhi examples and word joining rules. ● Introduction to Pāṇini and the Aṣṭādhyāyī. ● Dhātu, pratyaya, pada, and kāraka in simple terms. ● Basics of natural language processing: tokenization, morphology, and parsing. ● Exploration of Sanskrit digital dictionaries and Sanskrit reader tools. ● Comparison of grammar rules and computer program rules.	**5**	**CO6**

Text and Reference Books or Articles:

1. Acoustics of Chants, Conch-Shells, Bells & Gongs in Worship Spaces. Available: https://www.academia.edu/38208102/Acoustics_of_Chants_pdf?utm_source=chatgpt.com

2. V. R. S. Nalluri, V. J. K. S. Sonti, and G. Sundari, “Analysis of frequency dependent Vedic chanting and its influence on neural activity of humans,” International Journal of Reconfigurable and Embedded Systems, vol. 12, no. 2, pp. 230–239, Jul. 2023, doi: 10.11591/ijres.v12.i2.pp230-239.
3. The Garland Encyclopedia of World Music: South Asia. Available: https://api.pageplace.de/preview/DT0400.9781351544399_A30892028/preview-9781351544399_A30892028.pdf?utm_source=chatgpt.com
4. J. Pattanayak, Y. Belur, and J. Ilavarasu, “Acoustic and psychological effects of Omkar chanting in novice Indian adults: A quasi-experimental study,” Journal of Clinical and Diagnostic Research, 2025, doi: 10.7860/JCDR/2025/77365.21111. Available: https://www.jcdr.net/articles/PDF/21111/77365_CE%5BRa1%5D_F%28IS%29_QC%28PS_SS%29_PF1%28AB_IS%29_redo_PFA%28IS%29_PB%28AB_IS%29_PN%28IS%29.pdf?utm_source=chatgpt. com
5. “Indian Knowledge System: Integrating Heritage with Engineering” by Gagan Bansa, Deep Science Publishing; ISBN: 978-93-49307-77-3 E-ISBN: 978-93-49307-29-2;
6. The textbook of Indian Knowledge Systems, University of Mumbai, ISBN: 978-93-5915-553-1
7. Introduction to Indian Knowledge System: Concepts and Applications, Mahadevan, B., Bhat, Vinayak Rajat, Nagendra Pavana R.N. by PHI Learning Pvt Ltd. Delhi, ISBN: 978-93-91818-20-3
8. Echoes of the Monsoon: Ancient Indian techniques for predicting Rainfall, Janak Joshi, Kandarp
9. Parmar, Lakhan Jain, Sharmistha Bhowmik and Bindu Bhatt, DOI: https://www.doi.org/10.22271/27067483.2025.v7.i7a.386.
10. Kim Plofker, Mathematics in India: A clear historical overview of Indian mathematical developments, suitable for faculty use and advanced self-learners.
11. George Gheverghese Joseph, The Crest of the Peacock: An accessible introduction to non-European mathematical traditions, including India.
12. Charles Petzold, Code: The Hidden Language of Computer Hardware and Software: A beginner-friendly bridge from numbers and symbols to data representation and computing.
13. Simon Singh, The Code Book: Useful for simple explanations of ciphers, encryption, and the mathematics behind communication security.
14. T. A. Sarasvati Amma, Geometry in Ancient and Medieval India: A more specialized reference for deeper exploration of traditional mathematical methods.
15. Mahadevan, B., Bhat, V. R., and Nagendra Pavana R. N. Introduction to Indian Knowledge System: Concepts and Applications. PHI Learning.
16. Kapur, K., and Singh, A. K. (Eds.). Indian Knowledge Systems, Vol. 1. Indian Institute of Advanced Study, Shimla.
17. Bora, M. C. Bharatiya Knowledge Systems. Khanna Publishing House.
18. Rao, S. S. Engineering and Technology in Ancient India. Indian National Science Academy / related academic editions.
19. Selected open articles or chapters from IKS Division / AICTE / Ministry of Education resources may be used as supplementary reading.
20. S. D. Joshi and J. A. F. Roodbergen, The Aṣṭādhyāyī of Pāṇini.
21. V. N. Jha, The Philosophy of Sanskrit Grammar.
22. Peter M. Scharf, Sanskrit Syntax and Discourse Structures.
23. Daniel Jurafsky and James H. Martin, Speech and Language Processing — for introductory NLP concepts.
24. Rajeev Sangal, Akshar Bharati, and Vineet Chaitanya, Natural Language Processing: A Paninian Perspective.

Other Online References:

Sr. No.	Website Name
1.	NPTEL course page: For a structured academic overview of mathematics in India. https://nptel.ac.in/courses/111101080
2.	NPTEL YouTube playlist: For lecture-based learning that can support flipped or self-paced study. https://www.youtube.com/playlist?list=PLbMVogVj5nJThf31TNSQzuN7zqxe7HdRN
3.	IKS India: For broader Indian Knowledge Systems context and additional learning resources. https://www.nist.gov/cryptography
4.	Responsible AI and India-context resources: https://indiaai.gov.in/
5.	IKS Division, Ministry of Education / AICTE: https://iksindia.org/
6.	NPTEL: Introduction to Pāṇinian Grammar URL: https://onlinecourses.nptel.ac.in/noc24_hs44/preview
7.	Sanskrit Heritage Reader URL: https://sanskrit.inria.fr/

List of Experiments:

Sr No	List of Experiments	Hrs
01	Record a temple bell sound, conch sound, or classical "Sa" note and analyze it by plotting its time-domain waveform and frequency spectrum, identifying the fundamental frequency and harmonics, and comparing the observed harmonic structure with theoretical frequency ratios of Just Intonation and Equal Temperament.	04
02	Observe the movement of sunlight and shadow around a building, monument, or open courtyard at different times of the day, record the shadow directions and lengths, and analyze how solar position can guide orientation, time estimation, and passive architectural planning in the context of traditional Indian solar design.	04
03	Examine images, plans, or a simple model of the Konark Sun Temple or any sun-oriented structure, identify how geometry, orientation, and sunlight interaction are used in the design, and prepare a visual explanation of how ancient solar architecture supports modern sustainable building concepts.	04
04	Construct a small paper or cardboard windmill, test its rotation under natural wind or fan airflow at different speeds, and document how blade movement demonstrates the basic principle of converting wind energy into mechanical motion, linking it to traditional wind-powered systems and modern turbines.	04
05	Build a simple working model using cups, straws, thread, or cardboard to simulate water lifting or channel-based irrigation, observe how water can be moved with minimal energy input, and relate the model to ancient Indian irrigation systems and watermill-based practices.	04
06	Survey homes or nearby community spaces to identify traditional biomass fuels such as wood, agricultural residue, or cow-dung cakes, record their current use, benefits, and limitations, and compare the observed practices with modern ideas of bioenergy and sustainable fuel management..	04
07	Pronounce and classify selected Sanskrit sounds into vowels and consonants using a simple sound chart, group them according to articulation patterns, and analyze how this systematic sound organization supports pronunciation training, language learning, and speech-processing applications.	04
08	Create all possible combinations of short and long syllabic patterns of a fixed length, tabulate them systematically, and compare the resulting patterns with binary 0/1 combinations to understand how ancient combinatorial thinking connects with digital representation.	04
09	Solve real-life problems based on clocks, calendars, weekdays, or repeated events using modular arithmetic, record the remainder-based reasoning used in each case, and explain how cyclic patterns support time management, scheduling, and introductory cryptographic logic.	04

10	Convert selected decimal numbers into binary form, arrange them in bit patterns, append parity bits for even or odd parity, and interpret how binary representation and simple error-detection methods are used in digital systems for reliable data storage and transmission.	04
11	Use a basic Sanskrit dictionary, transliteration tool, or reader tool to input selected words, observe the output such as root, meaning, or grammatical analysis, and describe how such tools support language technology and digital preservation.	04
12	Select a real-life problem such as fake-news verification, waste segregation, or campus awareness, identify observation, evidence, inference, and conclusion using the basic framework of Indian logic, and represent the reasoning process as a decision tree, chatbot flow, or awareness tool concept.	04
13	Take a simple historical or rule-based calculation procedure associated with Indian mathematics, rewrite it as a sequence of input-process-output steps, and convert it into a flowchart to demonstrate the connection between procedural mathematics and modern algorithmic thinking.	04
14	Represent selected large and small numbers using a place-value table, deliberately insert or remove zero in different positions, and analyze how zero functions both as a number and as a placeholder, showing its importance in arithmetic, accounting, and digital data representation.	04
Sr No	**List of Assignments**	**Hrs**
01	Study the concepts of Nāda and Shruti, temple acoustics, and Vedic recitation methods, and briefly explain their relation to modern concepts of frequency, resonance, reverberation, and redundancy/error correction in digital communication systems. Also write a short note on how Indian Knowledge Systems demonstrate scientific understanding of sound and communication.	01
02	Study the ideas of solar architecture in traditional Indian structures such as the Konark Sun Temple or courtyard-based houses, and explain how sunlight, orientation, shading, and ventilation were used for thermal comfort and energy efficiency. Also write a short note on how these traditional design ideas are relevant to modern sustainable architecture and climate-responsive planning..	01
03	Study one traditional Indian renewable energy practice such as wind-powered water lifting, watermills, solar heating, or biomass use, and compare it with one modern renewable energy technology. Explain how traditional knowledge systems supported sustainable living and discuss how these ideas can inspire present-day energy conservation and green technology.	01
04	Study the basic ideas of Pāṇinian grammar as a structured rule-based system, and explain how concepts such as sounds, roots, suffixes, and word formation relate to modern ideas in natural language processing, machine translation, and language analysis. Also write a short note on why Sanskrit grammar is often considered relevant to computational linguistics.	01
05	Study the historical development of zero as both a number and a placeholder, and explain how the decimal place-value system simplified arithmetic and record keeping. Also write a short note on how zero and place value continue to be essential in digital computation, data storage, and computer-based numerical processing.	01
06	Study the basic ideas of Indian logic, especially observation, inference, debate, and evidence in the Nyāya tradition, and explain how these ideas support careful reasoning and decision-making. Also write a short note on how such logical methods can be applied in present-day contexts such as data analysis, fake-news verification, ethical decision-making, and responsible digital systems.	01
07	Identify one idea from Indian Knowledge Systems in the syllabus, such as renewable energy, Indian numeration, Indian logic, or Sanskrit grammar, and propose a simple real-life solution such as an app, chatbot, awareness campaign, digital archive, poster, database, or educational tool based on that idea. Explain the problem being addressed, the IKS principle used, and how the proposed solution can be useful in present-day society.	01
08	Study the basic Sanskrit grammar concepts of sounds, words, roots, suffixes, sandhi, and sentence structure, and explain how grammar rules work like structured instructions. Also compare grammar rules with computer program rules, and briefly discuss how tokenization, morphology, and parsing in computational systems resemble traditional rule-based language analysis.	01

Assessment:

Term Work:

Term work shall consist of at least 10-12 practical's based on above list. Also Term work Journal must include at least 4 assignments

Term Work Marks:

50 Marks (Total marks) = 25 Marks (Experiment) + 20 Marks (Assignments) + 5 Marks (Attendance)

Vertical 6

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
2276611	Data Structures	L	T	P	L	T	P	Total
		--	--	2*+2	--	--	2	2
		Examination Scheme						
			Term Work		Practical Exam		Total	
		Practical	25		-		25	

Pre-requisite Course Codes		
Course Outcomes	After the successful completion students should be able to	
	LO1	Implement various operations of linear data structures.
	LO2	Implement various operations of non-linear data structures.
	LO3	Develop solutions for real world problems by selecting appropriate data structure and algorithms.
	LO4	Analyze electronic Circuits using MOSFET, its DC and AC analysis
	LO5	Analyze the complexity of the given algorithms.

Module No.	Lab No.	Name of the experiment	Reference	Hrs.
Module 1		**Stack ADT: Operations on stack, Applications of stack**	1,2	6Hrs
	1	a. Implement Stack ADT using array b. Analyze time complexities of all operations of stack.		
	2	a. Convert Infix to Postfix and evaluate the postfix using Stack ADT		
Module 2		**Queue ADT : Operations on queue, Types of queues: Linear, Circular, Priority, Applications of queue**	1,2	6Hrs
	3	a. Implement Linear Queue ADT using array. **OR** b. Implement Circular Queue ADT using array		
	4	a. Implement Priority Queue ADT using array. b. Analyze time complexities of all operations of queue		
Module 3		**Linked List ADT, Types of Linked List: Singly, Circular, Doubly LL, Applications of linked list**	1,2	10 Hrs
	5	a. Implement following operations on Singly Linked List ADT. 1. Insert (all three) 2. Delete (all three) 3. Split 4. Concatenate 5. Copy 6. Reverse 7. Traverse b. Analyze time complexities of all operations of linked list		
	6	a. Implement following operations on Circular Linked List ADT 1. Insert (all three)		

		2. Delete (all three) 3. Traverse b. Analyze time complexities of all operations of circular linked list.		
	7	a. Implement Doubly Linked List ADT. 1. Insert (all three) 2. Delete (all three) 3. Traverse Forward 4. Traverse Backward b. Analyze time complexities of all operations of doubly linked list.		
	8	a. Addition of two polynomials using linked list		
Module 4		**Tree terminologies, Binary Tree, Tree traversal techniques, BST ADT, Expression Tree. Applications of Binary Tree**	1,2	10 Hrs
	9	a. Implement following operations on Binary Search Tree ADT using Linked List. 1. Insert 2. Delete (All three cases) 3. Search 4. Display b. Analyze the time complexities of all the operations on BST		
	10	Construct an expression tree from given postfix form of expression.		
	11	Implement a program to represent infix, prefix and postfix form of arithmetic expressions using binary tree traversal techniques. The expression is represented as a binary tree, where each operator is a parent node, and its operands are the left and right children		
Module 5		**Graph terminologies, Graph representations, Graph traversal techniques.**	1,2	4 Hrs
	12	Implement a program to represent a graph using an adjacency list or adjacency matrix data structure. Then, perform non recursive breadth first search (BFS)		
	13	Implement non recursive depth-first search (DFS) traversal algorithms on Graph represented using Adjacency matrix.		
Module 6		**Sorting: Insertion sort, selection sort, quick sort, merge sort**	1,2	6Hrs
	14	a. Implement Modified Bubble Sort, Insertion sort and Selection sort. b. Analyze the time complexity of the algorithms.		
	15	a. Implement Quick sort. b. Analyze the time complexity of the algorithm.		
	16	a. Implement Merge sort b. Analyze the time complexity of the algorithm		
Module 7		**Searching and Hashing: Binary search, Hashing, Hash functions, Collision resolution techniques**	1,2	6Hrs
	17	a. Implement the binary search algorithm to search for a key element in a sorted array. b. Analyze the time complexity of the algorithm		
	18	a. Implement a hash table data structure using an array and handle collisions using chaining (linked lists) b. Analyze the time complexity of the algorithm.		
	19	a. Implement a hash table data structure using an array and handle collisions using linear probing b. Analyze the time complexity of the algorithm		

Mini Project: (Suggested list of Mini Project Topics)				
		a. Text Edition Application: Implement a text editor with an undo feature using a stack. Every time a change is made to the text, push the previous state onto the stack. When the user performs an undo operation, pop the last state from the stack and revert the text to that state **b.** Develop a print job scheduler using a queue. Users submit print jobs to the queue, and they are processed in the order they were received. Once a job is completed, it is dequeued from the queue. **c.** Implement a task management system using a singly linked list. Each task is represented as a node in the linked list, containing information such as task description, priority, and deadline. Users can add, edit, delete, and search for tasks within the linked list **d.** Create a browser history manager using a doubly linked list. Each webpage visited is represented as a node in the linked list, with pointers to the previous and next pages. Users can navigate forward and backward through their browsing history, add new pages, delete visited pages, and search for specific pages. **e.** Implement a dictionary using a binary search tree (BST). Each node in the tree represents a word and its associated meaning. The tree is organized such that for any node, all words to the left have lexicographically smaller values, and all words to the right have lexicographically greater values. **f.** Given a network of cities connected by roads with different weights representing distances, find the minimum spanning tree to connect all cities with minimum total distance.		
			Total	**39**

Assessment:

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical/ Oral Exam: An Oral examination will be held based on the above syllabus.

Recommended Books:

1. "Data Structures using C and C++" Yedidyah Langsam, Moshe J. Augenstein, Aaron M. Tenenbaum
2. "Data Structures using C", Reema Thareja, Third Edition.
3. "Data Structures and Program Design in C++", Robert L. Kruse, Alexander J. Ryba, Prentice-Hall India.
4. "Data Structures and Algorithm in Java", Goodrich and Tamassia, John Wiley and Sons, Sixth Edition 2014.
5. "Data Structures and Pseudocode approach with C", 2nd Edition by Richard F. Gilberg & Behrouz A. Forouzan

Online References:

NPTEL courses on data structures

Term Work:

At least 10 experiments covering the entire syllabus of Data Structure should be set to have well predefined inference and conclusion. The experiments should be student centric and attempts should be made to make the experiments meaningful and interesting. Experiments must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Detail Syllabus
(Common Syllabus as per BoS Groups)

QUESTION PAPER PATTERN
(External and Internal)

Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result	Grading Point
9.00 - 10.00	90.0 – 100	O (Outstanding)	10
8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)	9
7.00 - < 8.00	70.0 - < 80.0	A (Very Good)	8
6.00 - < 7.00	60.0 - < 70.0	B+ (Good)	7
5.50 - < 6.00	55.0 - < 60.0	B (Above Average)	6
5.00 - < 5.50	50.0 - < 55.0	C (Average)	5
4.00 - < 5.00	40.0 - < 50.0	P (Pass)	4
Below 4.00	Below 40.0	F (Fail)	0
Ab (Absent)	-	Ab (Absent)	0

Sd/-

Dr. R. N. Awale
BoS-Chairman-Electronics and Computer Engineering
Faculty of Technology

Sd/-

Dr. Deven Shah
Associate Dean
Faculty of Science & Technology

Sd/-

Prof. Shivram S. Garje
Dean
Faculty of Science & Technology

AC –
Item No. –

As Per NEP 2020

University of Mumbai

Syllabus for Minor Vertical 1		
Faculty of Engineering		
Board of Studies in Automation & Robotics		
Third Year Programme in Minor (Automation & Robotics		
Semester	**V**	
Title of Paper (Theory)	**Sem.**	**Total Credits 4**
Sensors Actuators and Interfacing	**V**	**3**
Title of Paper (Lab)		**Credits**
Sensors Actuators and Interfacing Lab	**V**	**1**
From the Academic Year		**2026-27**

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2035211	Sensors Actuators and Interfacing	3	-	-	3	-	-	3

		Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
2035211	Sensors Actuators and Interfacing	20	20	40	60	2	--	--	100

Rationale:

Modern robotics and automation require sensors actuators and interfacing for intelligent interaction. Understanding sensors and actuators is essential for working with embedded systems, IoT, automation, robotics, and cyber-physical systems. This course emphasizes conceptual understanding, signal interpretation, and system integration.

Course Objectives:

1. To introduce basic measurement systems and sensor concepts used in industry.
2. To understand operating principles of commonly used industrial sensors.
3. To study basic characteristics and errors in sensor measurements.
4. To gain application-oriented knowledge of temperature, pressure, flow, and level sensors.
5. To understand actuators used in automation and embedded systems.
6. To introduce signal conditioning concepts through simple case studies.

Course Outcomes:

1. Evaluate measurement errors and standards for selecting sensors/transducers.
2. Apply and analyze temperature transducers in practical systems.
3. Identify and analyze pressure, vacuum, and level measurement devices.
4. Identify and analyze flow measurement techniques and transducers.
5. Apply and evaluate electrical/electromechanical actuators in automation.
6. Analyze signal conditioning requirements for temperature and pressure sensors

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	To understand this subject, student should have a foundational understanding of physics, especially regarding energy conversion and measurement. You should also be familiar with basic concepts of electronics and electrical signals.		
I	Measurement Systems & Sensors	1.1 Measurement system block diagram 1.2 Static and Dynamic characteristics of transducers. 1.3 Errors and its Types 1.4 Sensor classification and selection criterion	4	CO1

II	Temperature Sensors	2.1 Definition and units of temperature 2.2 Different temperature scales (^{0}C,^{0}F, ^{0}K,^{0}R,^{0}R') and their conversions 2.3 Resistance Temperature Detector (RTD): Working Principle (PT 100), 2 wire, 3 wire and 4 wire RTD Element, Lead wire compensation in RTD, Specifications, advantages, disadvantages and applications of RTD 2.4 Thermocouple: Working principle, See-beck effect, Peltier effect, Laws of thermocouple, types of thermocouples, cold junction compensation method, thermopile, Thermowell. Specifications, advantages, disadvantages and applications of Thermocouple 2.5 Thermistor, NTC & PTC Types, Specifications, advantages, disadvantages and applications of Thermistor 2.6 Pyrometers: Principle, construction and working of Radiation and Optical Pyrometers and its applications	6	CO2
III	Pressure, Vacuum & Level Sensors	3.1 Pressure units 3.2 Bourdon tube, diaphragm, strain gauge pressure sensors 3.3 Electrical/secondary Pressure Transducers: a) Bourdon tube with LVDT, b) Bellow with LVDT , c) Diaphragm with Strain gauge 3.4 Vacuum Measurement: Units and relations, Mcleod gauge 3.5 Calibration of Pressure Gauge 3.6 Level units, Classification ,construction, working, applications of : a) Direct method : methods- Sight glass, Hydrostatic type (air purge). b) Indirect measurement method: Float type with linear and rotary potentiometer, Capacitive type , Ultrasonic type, Nuclear Radiation type, Radar type Transducer.	10	CO3
IV	Flow Sensors	4.1 Introduction to fluid flow: types of fluid, Reynolds number, continuity equation. Bernoulli's equation 4.2 Head type: Orifice, Venturi, nozzle, pilot tube, characteristics of Head type flow meters, Variable area type: Rotameter 4.3 Velocity and Inertia based flow meters: Turbine, electromagnetic, ultrasonic, positive displacement meter - nutating disc type, Coriolis Mass flow meters.	6	CO4
V	Actuators	5.1 Definition and Classification: linear; rotary; Logical and Continuous Actuators 5.2 Electrical actuators, solenoids, motors (DC, AC, stepper), pneumatic and hydraulic actuators, piezoelectric actuators	8	CO5
VI	Case Studies & Signal Conditioning	6.1 Temperature Transducer signal conditioning Design: design considerations and application for RTD, Thermistor and thermocouple temperature sensor. 6.2 Pressure Transducer signal conditioning Design: design considerations and applications for various pressure sensors	5	CO6
		Total Hours	**39**	

Text Books:

1. B.C Nakra, K.K. Chaudhary, Instrumentation, Measurement and Analysis, Tata McGraw-Hill Education, 01-Oct-2003 - Electronic instruments - 632 page.
2. Patranabis D, Sensors and Transducers, Prentice Hall India Learning Private Limited; 2 edition (2003) - 344 pages.
3. A. K. Sawhney, Puneet Sawhney, A course in Electrical and Electronic Measurement and Instrumentation, Dhanpat Rai and Co. Rai, 1996.
4. Rangan, Mani, Sharma. Instrumentation systems and Devices, 2nd EdTata McGraw Hill.
5. D.V.S. Murthi, Instrumentation and Measurement Principles‖, PHI, New Delhi, 2nd ed. 2003.

References:

1. Doeblin E.D., Measurement system, Tata McGraw Hill., 4th ed, 2003.
2. Bela G. Liptak, Instrument Engineers' Handbook, Fourth Edition, Volume One: Process Measurement and Analysis, June 27, 2003.
3. W.G.Andrew, H.B.Williams, Applied Instrumentation in the Process Industries, Volume II – Gulf Publication Company , Paris, Tokyo.
4. Neubert Hermann K. P., Instrument Transducer, 2nd ed., Oxford University Press, New Delhi, 2003.
5. Johnson Curtis D., Process Control Instrumentation Technology, 8th Ed., 2005
6. S.P. Sukhatme, Heat Transfer, 3rd edition, University Press.
7. Chortle Keith R., Fundamentals of Test, Measurement Instrument Instrumentation, ISA Publication.
8. Alan S Morris, Measurement and Instrumentation Principles; 3rd Edition
9. Bansal R.K., ―Fluid Mechanics and Hydraulic Machines‖, Laxmi publications.
10. David W. Spitzer, ―Industrial Flow Measurement‖, ISA Publication

Online References:

Sr. No.	Website Name
1.	https://onlinecourses.nptel.ac.in/noc26_ee41/preview
2.	https://onlinecourses.nptel.ac.in/noc26_ee13/preview

Assessment:

Internal Assessment (IA) for 40 marks:

- IA will consist of Two Compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Examination for 60 Marks

Question paper format

- Question Paper will comprise of a total of six questions each carrying 15 marks Q.1 will be compulsory and should cover maximum contents of the syllabus
- Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of Four questions needs to be answered
- A total of **Four questions** needs to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2035212	Sensors Actuators and Interfacing Lab	--	02	-	--	01	-	01

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Avg. of 2 Tests				
2035212	Sensors Actuators and Interfacing Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To understand the principle of various Transducers
2. To experimentally verify the characteristics of Temperature transducers
3. To experimentally verify the characteristics of Pressure, vacuum and level transducers.
4. To experimentally verify the characteristics of flow transducers.
5. To explore and analyze various types of actuators
6. To design and implement signal conditioning circuits for temperature and pressure transducers.

Lab Outcomes

1. Understand the fundamental principles and classifications of various transducers, including their working mechanisms and applications in measuring physical parameters.
2. Experimentally analyze the characteristics of temperature transducers such as RTDs, thermistors, and thermocouples, and interpret their response to temperature variations.
3. Experimentally analyze the characteristics of pressure, vacuum, and level transducers through practical experiments, understanding their behavior under different conditions.
4. Experimentally analyze the characteristics of flow transducers, interpreting their output in relation to varying flow rates.
5. Analyze various types of actuators, understanding their construction, operation, and applications in Automation.
6. Design and implement signal conditioning circuits tailored for temperature and pressure transducers, ensuring accurate signal processing for reliable measurem

List of Experiments.

Sr No	List of Experiments	Hrs
01	Demonstrate the basic measurements techniques and Measuring Instruments.	2
02	Plot and validate the LVDT characteristics.	2
03	Plot and validate the strain gauge characteristics	2
04	Plot and validate the characteristics of RTD	2
05	Draw and validate the characteristics of various Thermocouples.	2
06	Draw and validate the characteristics of Thermistors.	2
07	Test and compare temperature measurement with and without Thermo-well.	2
08	Plot and validate performance characteristics of Hydrostatic type (air purge) system.	2
09	Identify constant head type flow sensors such as Orifice and study the applications.	2
10	Identify constant head type flow sensors such as Venturi tube and study the applications.	2
11	Identify variable area such as Rotameter and study the applications.	2
12	Study of Linear and Rotary Actuators	2
13	Speed and Direction Control of AC Motor	2
14	Speed and Direction Control of DC Motor	2

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Sr No	List of Assignments / Tutorials	Hrs
01	Assignment based on classification, specification and selection criteria of transducer	
02	Assignment based on types of temperature transducers	
03	Assignment based on types of Pressure and vacuum transducers	
04	Assignment based on types of level transducers	
05	Assignment based on types of flow transducers	
06	Assignment based on types of Actuators	

Assessment:

Term Work: Term Work shall consist of at least 10 practical's based on the above list.
Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)
Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

AC –
Item No. –

As Per NEP 2020

University of Mumbai

Syllabus for Minor Vertical 2		
Faculty of Engineering		
Board of Studies in Automation & Robotics		
Third Year Programme in Minor (Automation & Robotics		
Semester	**VI**	
Title of Paper (Theory)	**Sem.**	**Total Credits 4**
Robotics and Automation System	**VI**	**3**
Title of Paper (Lab)		**Credits**
Robotics and Automation System Lab	**VI**	**1**
From the Academic Year		**2026-27**

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2036211	Robotics and Automation System	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
2036211	Robotics and Automation System	20	20	40	60	2	--	--	100

Rationale:

This course provides foundational knowledge of automation and robotics systems used in modern industries. It introduces students to automation tools, robotic components, mechanics, kinematics, dynamics, and motion planning. The course equips learners with the ability to apply and analyze automation and robotic principles required for industrial applications, higher studies, and emerging technologies in automation and robotics.

Course Objectives:

1. To understand basics of automation systems and their applications.
2. To learn fundamentals of robotics, components, configurations, and safety.
3. To apply engineering mechanics concepts in robotics.
4. To understand transformations and coordinate systems in robotics.
5. To study kinematics of robotic arms.
6. To learn robot dynamics and motion planning.

Course Outcomes

1. Apply automation systems and tools in industrial automation applications.
2. Analyse robotic systems based on structure, joints, end effectors, and specifications.
3. Apply engineering mechanics principles to robotic systems.
4. Apply transformation matrices and DH parameters for robot manipulators.
5. Analyze forward and inverse kinematics and Jacobian of robotic arms.
6. Analyze robot dynamics and motion planning techniques.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	To understand this subject, student should have a foundational understanding of sensors, actuators		
I	**Basics of Automation System**	1.1 Need and benefits of automation system 1.2 Application areas: Process industries, building, robotics, railways, infrastructure development, aerospace, automobiles electrical distribution, medical, telecommunication etc. 1.3 Automation hierarchy: Basic components and function of each component 1.4 Types of automation system: Fixed, programmable, flexible machine automation, process automation, factory automation 1.5 Different systems used in industrial automation: PLC, HMI, SCADA, DCS, drives	5	CO1
II	**Fundamentals of Robotics**	2.1 Definition, brief history, Asimov‘s laws of robot, robot anatomy: Base, manipulator arm, end effectors, sensors, control system, actuators. 2.2 Robotics: Block diagram and function of each component (sensors, drive system, control system, end effectors) 2.3 Construction and degrees of freedom of cylindrical robot 2.4 Construction and degrees of freedom of spherical and cartesian robots	4	CO2
III	**Basics of Engineering Mechanics for Robotics**	3.1 Introduction of mechanics: Engineering mechanics, statics, concept of rigid body, force: Definition, unit, Bow’s notation, characteristics, types of force system 3.2 Moment of force: Definition, unit, sign conventions 3.3 Equilibrium of forces: Definition, conditions, simple numerical on equilibrium 3.4 Centroids and centre of gravity: Concept, definition	6	CO3
IV	**Transformations used in Robotics**	3.1 Kinematics: Definition and significance, coordinate system and frames in robotics, reference and body frames, pose of a rigid body 3.2 Rotation matrix: Representation of orientation, concept of roll, pitch, yaw motion, elementary rotation matrix about Z axis (derivation), elementary rotation matrix about X axis and Y axis (only formula) 3.3 Coordinate transformation matrix: Description, equation, homogeneous transformation matrix (HTM)-equation, description, numerical 3.4 DH (Denavit–Hartenberg) parameters, DH rules,	10	CO4

		DH table for the given manipulator such as 2R, 2P,3P, 3R, SCARA 3.5 Transformation between DH frames and the corresponding HTM		
V	**Kinematics of the Robotic Arm**	4.1 Position analysis: Concept of forward position analysis / kinematics and inverse position analysis / kinematics 4.2 Forward position analysis for 2P and 2R planar arm 4.3 Definition of linear and angular displacement, linear and angular velocity, linear and angular acceleration 4.4 Differential motion and velocities of robot: Jacobian equation in robotics, Jacobian matrix in robotics 4.5 Simple Numerical on Jacobian matrix based on the end-effector's coordinates and joint parameters.	6	CO4
VI	**Dynamics of the Robotic Arm and Motion Planning**	5.1 Dynamics: Definition, concept of forward and inverse dynamics 5.2 Dynamic equations of motion for joints of robot manipulators: Lagrange-Euler and Newton-Euler equations (no derivation, only simple numerical based on equations) 5.3 Motion planning: Concept, joint space planning, cartesian space planning 5.4 Cartesian trajectories: Concept, point to point and continuous path motion	8	CO5
		Total Hours	**39**	

Text Books:

1. R. K. Rajput, *Robotics and Industrial Automation*, S. Chand Publishing, 2008 – Robotics and industrial automation basics – approx. 461 pages Google Books
2. A. K. Gupta & S. K. Arora, *Industrial Automation and Robotics*, Laxmi Publications Pvt Ltd, 2007/2012 – Introduction to automation systems and robotics – approx. 348 pages Google Books
3. Khushdeep Goyal & Deepak Bhandari, *Industrial Automation & Robotics*, S.K. Kataria & Sons, 5th ed. 2015 – Automation and robotics fundamentals – approx. 350 pages

Reference books

1.Ashitava Ghosal, *Robotics: Fundamental Concepts and Analysis*, Oxford University Press, 2010 fundamentals, kinematics, dynamics & control – approx. 688 pages.
2.M. R. Chidambara, *Robots and Robotics*, National Book Trust (NBT), 2016 – Introduction to rob applications – approx. 240 pages.
3.R. K. Mittal & I. J. Nagrath, *Robotics and Control*, Tata McGraw-Hill Education, 2010 – Roboti kinematics, dynamics & control – approx. 672 pages.
4. K. K. Aggarwal & N. B. Nair, *Industrial Robotics*, Tata McGraw-Hill Education, 1991 – Industr fundamentals and applications – approx. 332 pages.
5. S. K. Saha, *Introduction to Robotics*, McGraw-Hill Education India, 2008 – Robotics basics, des sensors and control – approx. 480 pages.
6. G. C. Jawalkar, S. R. Godbole & V. P. Thakker, *Industrial Robotics*, McGraw-Hill Education, 2(Industrial automation and robotics systems – approx. 552 pages.

Online References:

Sr. No.	Website Name
1.	https://onlinecourses.nptel.ac.in/noc26_me36/preview
2.	https://onlinecourses.nptel.ac.in/noc26_me72/preview

Assessment:

Internal Assessment (IA) for 40 marks:

- IA will consist of Two Compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Examination for 60 Marks

Question paper format

- Question Paper will comprise of a total of six questions each carrying 15 marks Q.1 will be compulsory and should cover maximum contents of the syllabus
- Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of Four questions needs to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2036212	Robotics and Automation System Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test 1	Test 2	Avg. of 2 Tests				
2036212	Robotics and Automation System Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To study industrial PLCs, hardware, software, and I/O devices.
2. To understand robot manipulators, joints, and grippers using OSS.
3. To verify law of moments and centroid of plane figures.
4. To analyze rotation matrix, HTM, and DH parameters.
5. To study forward and inverse kinematics of robots.
6. To analyze Jacobian, dynamics, and trajectory planning.

Lab Outcomes

1. Apply knowledge to identify PLC components and I/O devices.
2. Analyze robot joints, motion, and gripper operation.
3. Apply law of moments and centroid principles.
4. Analyze rotation matrix, HTM, and DH parameters.
5. Apply forward and inverse kinematics solutions.
6. Analyze robot motion, dynamics, and trajectories.

List of Experiments: Minimum **TEN** experiments to be performed

List of Experiments.

Sr No	List of Experiments	Hrs
01	Identification of major industrial PLC available in market which are used for industrial process	
02	Identification of hardware and software of PLC automation system with virtual lab	
03	Identification of various input and output devices used in PLC system available in laboratory	
04	Analysis of robot manipulator movement using 3D model based open source software (OSS)	

05	Working of different type of joints used in robots using 3D model based OSS	
06	Operation of a 2-finger pneumatic and vacuum parallel gripper of a robot	
07	Verification of law of moment of forces using law of moment apparatus .	
08	Verification of centroid of given plane	
09	Determination of the rotation matrix of the given manipulator along any given axis using OSS	
10	Determination of the HTM for rotation and translation for the given robot manipulator using 3D model based OSS	
11	Analysis of DH table for different values of DH parameters of a given robot manipulator using 3D model based OSS	
12	Determine the HTM for different values of DH parameters of a given robot manipulator for various links using 3D model based OSS	
13	Determination of the position and orientation of end effector of a 4 axis/6 axis robot using forward kinematics	
14	Determination of the joint angle for the given position of the end effector of a 4 axis/6 axis robot using inverse kinematics	
15	Derivation of Jacobian matrix using OSS for the given manipulator	
16	Determination of the position and orientation of the end effector for the given force at the joint of a 4 axis/6 axis robot using forward dynamics	
17	Determination of the forces required at the joint from the position and orientation of the end effector of a 4 axis/6 axis robot using inverse dynamics	
18	Interpolation of Cartesian space trajectories of the given 4axis/6axis robot manipulator	
19	Interpolation of the joint space trajectories of the given 4 axis/6 axis robot manipulator	

Sr No	List of Assignments / Tutorials	Hrs
01	Study and compare different industrial PLCs and their applications.	2
02	Draw and explain the PLC system with hardware, software, and I/O devices.	2
03	Analyze different types of robot joints and gripper mechanisms.	2
04	Solve problems on law of moments and centroid of plane figures.	2
05	Compute rotation matrix, HTM, and DH parameters for a manipulator.	2
06	Solve numerical problems on kinematics, dynamics, and trajectory planning.	2

Assessment:

Term Work: Term Work shall consist of at least 10 practical's based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.