SOMAIYA
VIDYAVIHAR

K J Somaiya Institute of Technology
An Autonomous Institute Permanently Affiliated to the University of Mumbai

Item No.
A.C. Date: --/--/2026

Autonomy Syllabus Scheme III (2023-24)

(As per NEP 2020 Guidelines)

for

Four Year Multidisciplinary

Bachelors of Technology (B. Tech.) Program

in

Electronics and Telecommunication Engineering with

Multiple Entry and Multiple Exit Options

Levels 4.5 - 6

(Last Year Effective from A.Y. 2025-26)

From the Principal's Desk:

To address the changing demands of the digital era, it is required to create a future-ready workforce that can navigate the complexities of an interconnected world, drive innovation, and contribute to the nation's growth. The **National Educational Policy 2020 (NEP 2020)** framed by the Government of India recommends a holistic, inclusive, and flexible approach to ensure equitable access to quality education across all levels, promote multidisciplinary research, and impart skill-based education with integration of technology. As per guidelines by the Department of Higher and Technical Education, Government of Maharashtra, the salient features of NEP 2020 aligned curriculum should include:

- Major (Core) Mandatory and Elective Courses
- Open Elective Courses
- Vocational and Skill Enhancement Courses
- Ability Enhancement Courses, Indian Knowledge System, and Value Education Courses
- Co-curricular Courses and Field Projects / Community Engagement Projects / Internship
- Multidisciplinary Minor Courses
- Option for Bachelor's Degree with Honours (based on Additional Credits)
- Option for Bachelor's Degree – Honours with Research (based on Additional Credits)
- Option for Bachelor's Degree with Double Minors (based on Additional Credits)
- Multiple Entry and Multiple Exit Options

Being an **autonomous institute** since the Academic Year 2021-22, **K. J. Somaiya Institute of Technology (KJSIT)**, has well-adapted newer approaches to reach higher levels of excellence in engineering education. Ahead of its time, the academic reforms at KJSIT have already addressed majority of these NEP 2020 aspects through its existing **Syllabus Scheme I, II, and II B** implemented under the academic autonomy. For a complete alignment with NEP 2020, the **KJSIT Autonomy Syllabus Scheme III** is introduced, to be effective from Academic Year 2023-24 across all the branches, progressively from First Year Engineering.

Specifically, the existing curriculum already comprise state-of-the-art **Major (Core) courses** in theory and practical. With an ideology that the root of innovation is 'interest', the curriculum offers wide range of Elective courses — grouped into **Major-related Electives** and **Inter-disciplinary / Open Electives**. At par with international engineering education, it follows a learner-centric approach as well as promotes MOOCs, where the students can choose to study courses concerning areas of their interests, and the same is continued in Scheme III.

Further, under the theme of "Learning by Doing", the existing curriculum includes Skill-Based Learning (SBL), Activity-Based Learning (ABL), and Technology-Based Learning (TBL) as eXposure (SAT) courses — that assure X factor in all the students of the institute. The SAT courses are practiced across the first three years of engineering, focusing on responsibilities towards society, problem-solving abilities, communication skills, ethics, leadership and teamwork, motivation for life-long learning, skills on emerging areas of technology, skills on different languages, etc. In the Syllabus Scheme III, these SAT courses are now aligned and offered as **Vocational Skill - SAT (VS - SAT) courses**, **Skill Enhancement - SAT (SE - SAT) courses**, **Ability Enhancement - SAT (AE - SAT) courses**, and **Value Education - SAT (VE - SAT) courses**.

Further, **Indian Knowledge System - SAT (IKS - SAT) course** is newly introduced in Scheme III that emphasizes on drawing insights from ancient wisdom to address modern challenges. Also, as an extension to the induction program for the First Year students, the introduced **Co-curricular - SAT (CC - SAT) course** aims to induct incumbents with the institutional practices, culture, and values, as well as encourage participation in co-curricular activities.

The component of **Project-Based Learning (PBL)** included in the Syllabus Scheme II is carried forward to Scheme III, wherein the students develop **Community Engagement / Field Projects** in Second, Third, and Last Year as Mini, Minor, and Major Projects respectively. Scheme III also retains the **Internship** component, offered with credits, to equip graduates with the industry trends, practices, and skills required at national and global level.

The duality of PBL and Internship enables student involvement in research, innovation, and entrepreneurship, which are the fulcrums of higher education.

As a new introduction in line with NEP 2020, the Syllabus Scheme III incorporates mandatory **Multidisciplinary Minor courses** in Innovation and Entrepreneurship, Biotechnology, IoT and Cloud Computing, Geographical Information System, Very Large Scale Integration (VLSI) and Artificial Intelligence. These courses promote interdisciplinary thinking and broaden the career prospects, enabling students to develop solutions to real-world problems by combining expertise from multiple domains.

Aligned with NEP 2020, the Scheme III retains the initiative taken through Scheme II / II B of offering **Honours courses** for students who are desirous of pursuing focused interest in 06 emerging areas of technology recognized by AICTE: Internet of Things, Artificial Intelligence & Machine Learning, Cyber Security, Virtual and Augmented Reality, Data Science, and Blockchain. These Honours courses correspond to high-end industry standards and offer multi-fold opportunities of specialization.

As per NEP 2020, the above curricular aspects of Four Years UG Engineering Programme shall be offered with **Multiple Entry and Multiple Exit options**, leading to the conferment of:

- **One Year UG Certificate in Technology:** Awarded after completing First Year of Engineering and acquiring additional 08 credits immediately after First Year.
- **Two Years UG Diploma in Technology:** Awarded after completing Second Year of Engineering and acquiring additional 08 credits immediately after Second Year.
- **Three Years Bachelor's Degree in Vocation (B.Voc.):** Awarded after completing Third Year of Engineering and acquiring additional 08 credits immediately after Third Year.
- **Four Years Bachelor's Degree in Technology (B.Tech.) with Multidisciplinary Minor:** Awarded after completing Fourth Year of Engineering.
- **Four Years Bachelor's Degree in Technology (B.Tech.) Honors with Multidisciplinary Minor:** Awarded after completing Fourth Year of Engineering and acquiring additional 18 credits through Honours courses in respective major discipline over Third & Fourth Year of Engineering.
- **Four Years Bachelor's Degree in Technology (B.Tech.) Honors with Research and Multidisciplinary Minor:** Awarded after completing Fourth Year of Engineering and acquiring additional 18 credits through a research project in respective major discipline during Fourth Year of Engineering.
- **Four Years Bachelor's Degree in Technology (B.Tech.) with Double Minors (Multidisciplinary & Specialization):** Awarded after completing Fourth Year of Engineering and acquiring additional 18 credits through additional courses in another Engg. / Tech. discipline during Second to Fourth Year of Engineering.

Through the implementation of Autonomy Syllabus Scheme III (as per NEP 2020 Guidelines), strategic planning, and joint efforts of all stakeholders, KJSIT is endeavouring to enhance the quality of engineering education and set a benchmark for all the autonomous institutes nationwide.

Dr. Vivek Sunnapwar
Principal and Chairman - Academic Council

Preface by Chairperson – Board of Studies (BoS):

In today's world, lot of technological developments are taking place in the field of Electronics & Telecommunication Engineering in order to meet the current requirements. Hence, there is always a requirement for continuous enrichment of course content in the field of education on regular basis to maintain a good quality of education by the regular revision of curriculum. This will help our students with the upgraded knowledge, help in achieving better employability, opportunities to work with start -ups, chances for good internships at premier organizations/industries and other avenues of higher studies.

The revised curriculum of Scheme-III (Electronics and Telecommunication Engineering) under the autonomy has focussed on all these above mentioned factors and aims to provide strong foundation along with required analytical concepts in the field of electronics & telecommunication. The curriculum is designed keeping in mind the guidelines of NEP-2020. Some of the salient features of the syllabus are as mentioned below.

1. The curriculum is designed with a total of number of 174 credits along with the inclusion of Skill, and Technology and Project based learning.

2. The skill based courses are introduced in the second and third year in which students are exposed to hard/ soft skills. Students are also introduced with the community engagement projects in the second year in current technologies.

3. Third year students are introduced with technology based learning along with skill based courses. The community engagement projects are introduced to the third year students in the specialized core fields

4. Students are introduced to National/Foreign Languages in the second year to make them proficient at job locations as per the requirement.

5. The curriculum is designed to incorporate the electives in (department and institute level) covering the thrust areas that will provide more focussed approach for the students in problem solving and also to be at par with the current industry requirements.

6. The contents of the curriculum is designed taking into consideration the IT domain developments into account and at the same time keeping the focus on core specialization of the program intact

7. The internships are made mandatory and credit based for all the students in semester VIII. The students are provided with the flexibility to carry out internship for entire semester. That helps them to acquaint with the industry work culture

As Chairman BOS, I take this opportunity to thank all the internal and external BOS members, subject experts, industry representatives, alumni, and various other stakeholders for their sincere efforts and valuable inputs in the preparation of course contents, in reviewing the contents and critically analysing the contents.

Dr. Jayashree V. Khanapuri
Head and Chairperson,
Electronics and Telecommunication Engineering Department, KJSIT

Board of Studies (BoS) in Electronics and Telecommunication Engineering – K. J. Somaiya Institute of Technology (KJSIT):

1. **Dr. Jayashree Khanapuri**
   Professor and Head – Department of Electronics and Telecommunication Engineering,
   Chairperson – BoS in Electronics and Telecommunication Engineering, KJSIT
2. **Dr. Namrata Ansari**
   Professor – Department of Electronics and Telecommunication Engineering and Dean – Academics, KJSIT
3. **Ms. Vricha Chavan**
   Assistant Professor – Department of Electronics and Telecommunication Engineering, KJSIT
4. **Dr. Sandhya Kadam**
   Assistant Professor – Department of Electronics and Telecommunication Engineering, KJSIT
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7. **Dr. Kiran Rathod**
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    Assistant Professor – Department of Electronics and Telecommunication Engineering, KJSIT
12. **Ms. Rupali Satpute**
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16. **Mr. Amit Kukreja**
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18. **Ms. Sandhya Deshpande**
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19. **Dr. Priya Hankare**
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20. **Ms. Swati Shinde**
    Assistant Professor – Department of Electronics and Telecommunication Engineering, KJSIT
21. **Mr. Sagar Mhatre**
    Assistant Professor – Department of Electronics and Telecommunication Engineering, KJSIT
22. **Dr. Deepak Bhoir**
    Professor and Dean Academics, Fr. Conceicao Rodrigues College of Engineering, Bandra, Mumbai
23. **Dr. Virendra Shete**
    Professor, MIT – School of Engineering, Pune
24. **Dr. Vivek Agarwal**
    Professor, Department of Electrical Engineering, IIT Bombay
25. **Mr. Alister D'silva**
    Director, Absolute Motion Pvt. Ltd., Mumbai

Nomenclature and Alignment of Verticals and Components

Verticals as per NEP 2020 Guidelines	Components Aligning with KJSIT Autonomy Syllabus Scheme I / II / II B	Nomenclature for KJSIT Autonomy Syllabus Scheme III Aligned with NEP 2020 Guidelines
Basic and Engineering Science Courses	Basic Science (BS) Course	Basic Science (BS) Courses
	Engineering Science (ES) Course	Engineering Science (ES) Courses
Major Courses	Professional Core (PC) Courses	Major / Professional Core (PC) Courses
	Professional Elective - Department-level (PE-DLC) Courses	Major / Professional Elective - Department-level (PE-DLC) Courses
Generic / Open Elective Courses	Open Elective - Institute-level (OE-ILC) Courses	Open Elective - Institute-level (OE-ILC) Courses
Multidisciplinary Minor Courses	-	Multidisciplinary Minor (MM) Courses
Vocational Skill Courses	Workshop I; Workshop II; SAT Courses – TBL	Vocational Skill - SAT (VS-SAT) Courses
Skill Enhancement Courses	SAT Courses – SBL (Program Specific)	Skill Enhancement - SAT (SE-SAT) Courses
Ability Enhancement Courses	Professional Communication Skills; SAT Course – SBL (Foreign and/or Indian Modern Languages)	Ability Enhancement - SAT (AE - SAT) Courses
Indian Knowledge System Courses	-	Indian Knowledge System - SAT (IKS - SAT) Courses
Value Education Courses	SAT Course – ABL (National, Global, Societal and Environmental Aspects); Business Communication & Ethics	Value Education - SAT (VE - SAT) Courses
Field Projects / Community Engagement Projects	PBL – Mini, Minor, Major	Community Engagement – Project-Based Learning (PBL)
Internship / Apprenticeship	Internship	Internship (INT)
Co-curricular Courses	Student Induction Program	Co-curricular - SAT (CC - SAT) Courses

Other Abbreviations:

- SAT – Skill/Activity/Technology-Based Learning (Exposure Courses)
- TH – Theory
- P – Practical
- TUT – Tutorial
- T1 – Test 1
- T2 – Test 2
- CA – Continuous Assessment Test (T = T1 + T2)
- ESE – End Semester Exam
- TW – Term Work
- O – Oral Exam
- P – Practical Exam
- P&O – Practical & Oral Exam

Programs Offered with Multiple Entry Multiple Exit Options

Level 4.5: UG Certificate in Technology

Major Discipline:	Electronics and Telecommunication Engineering
Years of Study:	01 Year
Semesters:	1 and 2
Credits:	42
Additional Requirements:	08 Credit Bridge Course Corresponding to Skill-Based Courses / Internship / Mini Projects in Major during Summer Vacation after 1st Year

Level 5: UG Diploma in Technology

Major Discipline:	Electronics and Telecommunication Engineering
Years of Study:	02 Years
Semesters:	1, 2, 3, 4
Credits:	85
Additional Requirements:	08 Credit Bridge Course Corresponding to Skill-Based Courses / Internship / Mini Projects in Major during Summer Vacation after 2nd Year

Level 5.5: Bachelor's Degree in Vocation (B. Voc.)

Major Discipline:	Electronics and Telecommunication Engineering
Years of Study:	03 Years
Semesters:	1, 2, 3, 4, 5, 6
Credits:	130
Additional Requirements:	08 Credit Bridge Course Corresponding to Skill-Based Courses / Internship / Mini Projects in Major during Summer Vacation after 3rd Year

Level 6: B.Tech. in Technology with Multidisciplinary Minor

Major Discipline:	Electronics and Telecommunication Engineering
Offered Multidisciplinary Minors:	• Innovation and Entrepreneurship • Biotechnology • IoT and Cloud Computing • Geographical Information System • VLSI • Artificial Intelligence
Years of Study:	04 Years
Semesters:	**Major –** 1, 2, 3, 4, 5, 6, 7, 8 **Multidisciplinary Minors** – 4, 5, 6
Credits:	174

Level 6: B.Tech. in Technology - Honors and Multidisciplinary Minor

Major Discipline:	Electronics and Telecommunication Engineering
Offered Honors and Multidisciplinary Minors:	**Honors:** • Internet of Things* • Artificial Intelligence & Machine Learning • Cyber Security • Virtual and Augmented Reality • Data Science • Blockchain **Multidisciplinary Minors:** • Innovation and Entrepreneurship • Biotechnology • IoT and Cloud Computing* • Geographical Information System • VLSI • Artificial Intelligence * Can be chosen for either Honors or Minors, not both
Years of Study:	04 Years
Semesters:	**Major –** 1, 2, 3, 4, 5, 6, 7, 8 **Multidisciplinary Minors** – 4, 5, 6 **Honors** – 5, 6, 7, 8
Credits:	192 (= Major with Multidisciplinary Minors: 174 + Honors: 18)

Level 6: B.Tech. in Technology - Honors with Research and Multidisciplinary Minor

Major Discipline:	Electronics and Telecommunication Engineering
Offered Multidisciplinary Minors:	• Innovation and Entrepreneurship • Biotechnology • IoT and Cloud Computing • Geographical Information System • VLSI • Artificial Intelligence
Years of Study:	04 Years
Semesters:	**Major –** 1, 2, 3, 4, 5, 6, 7, 8 **Multidisciplinary Minors** – 4, 5, 6 **Honors with Research** – 7, 8
Credits:	192 (= Major with Multidisciplinary Minors: 174 + Honors with Research: 18)

Level 6: B.Tech. in Technology with Double Minors (Multidisciplinary & Specialization)

Major Discipline:	Electronics and Telecommunication Engineering
Offered Multidisciplinary Minors and Specialization Minors:	**Multidisciplinary Minors:** • Innovation and Entrepreneurship • Biotechnology • IoT and Cloud Computing • Geographical Information System • VLSI • Artificial Intelligence **Specialization Minors:** 06 additional courses (of minimum 12 week each), in another Engg. / Tech. discipline / Emerging Areas through MOOC
Years of Study:	04 Years
Semesters:	**Major –** 1, 2, 3, 4, 5, 6, 7, 8 **Multidisciplinary Minors** – 4, 5, 6 **Specialization Minors** – 3, 4, 5, 6, 7, 8
Credits:	192 (= Major with Multidisciplinary Minors: 174 + Specialization Minors: 18)

Credit Distribution Structure for Four Year Multidisciplinary B.Tech. Degree Program in Electronics and Telecommunication Engineering with Multiple Entry Multiple Exit Options

Level	Semester	Faculty: Science and Technology					Faculty: Any	Vocational Skills (VS) & Skill Enhancement (SE) Courses		Ability Enhancement (AE), Indian Knowledge System (IKS), Value Education (VE) Courses			Field Projects / Community Engagement (CE) Projects, Internship (INT), and Co-curricular (CC) Courses			Credits	Cumulative Credits
		Basic Science (BS) Courses	Engineering Science (ES) Courses	Major / Professional Core (PC) Courses	Major / Professional Elective - Department-level (PE-DLC) Courses	Multi-disciplinary Minor (MM) Courses	Open Elective - Institute-level (OE-ILC) Courses	VS - SAT Courses	SE - SAT Courses	AE - SAT Courses	IKS - SAT Courses	VE - SAT Courses	CE - Project-Based Learning (PBL)	INT	CC - SAT Courses		
Level 4.5	I	9	8					1				1			2	21	42
	II	9	8					1		2	1					21	
Exit Option with UG Certificate in Technology with Additional 08 Credit Bridge Course Corresponding to Skill-Based Courses / Internship / Mini Projects in Major																	
Level 5.0	III	4		15					1				1			21	85
	IV	4		11		4			1	1			1			22	
Exit Option with UG Diploma in Technology with Additional 08 Credit Bridge Course Corresponding to Skill-Based Courses / Internship / Mini Projects in Major																	
Level 5.5	V			11	4	3			1			2	1			22	130
	VI			8	4	3	3	2					3			23	
Exit Option with Bachelor's Degree in Vocation (B. Voc.) with Additional 08 Credit Bridge Course Corresponding to Skill-Based Courses / Internship / Mini Projects in Major																	
Level 6.0	VII			8	7		3						6			24	174
	VIII			8										12		20	
Total		**26**	**16**	**61**	**15**	**10**	**6**	**4**	**3**	**3**	**1**	**3**	**12**	**12**	**2**	**174**	

Program Structure for Last Year UG Technology (EX)

SEMESTER VII

TEACHING SCHEME

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		Course Category
		TH – P – TUT	Total	TH – P – TUT	Total	
EXC701	Microwave Engineering	3 – 0 – 0	03	3 – 0 – 0	03	PC
EXC702	Mobile Communication Systems	3 – 0 – 0	03	3 – 0 – 0	03	PC
EXDLC703	Major / Professional Elective - Department-level Course – III	3 – 0 – 0	03	3 – 0 – 0	03	PE-DLC
EXDLC704	Major / Professional Elective - Department-level Course – IV	3 – 0 – 0	03	3 – 0 – 0	03	PE-DLC
ILC705	Open Elective - Institute-level Course – II	3 – 0 – 0	03	3 – 0 – 0	03	OE-ILC
EXL701	Microwave Engineering Laboratory	0 – 2 – 0	02	0 – 1 – 0	01	PC
EXL702	Mobile Communication Systems Laboratory	0 – 2 – 0	02	0 – 1 – 0	01	PC
EXDLL704	Major / Professional Elective - Department-level Course – IV Lab	0 – 2 – 0	02	0 – 1 – 0	01	PE-DLC
EXPR75	Community Engagement PBL - Innovation-Based Major Project B	0 – 12 – 0	12*	0 – 6 – 0	06	PBL
Total		**15 – 18 – 0**	**33**	**15 – 9 – 0**	**24**	

*Load of learner, not the faculty.

Professional Electives - Department Level Elective Courses & Labs (PE-DLC – III & PE-DLC – IV)

Department Level Elective Courses	Course Code	Course Name
Major / Professional Elective - Department-level Course – III	EXDLC7031 EXDLC7032 EXDLC7033 EXDLC7034 EXDLC7035	Natural Language Processing Satellite and Nano Satellite Communication Embedded Systems & RTOS Big Data Analytics RF Design
Major / Professional Elective - Department-level Course – IV	EXDLC7041 EXDLC7042 EXDLC7043 EXDLC7044 EXDLC7045	Neural Network and Deep Learning Wireless Networks Autonomous Vehicle Cloud Computing & Security System On-Chip

Institute Level Course	Course Code	Course Name #
Open Elective – Institute-level Course – II	ILC7051 ILC7052 ILC7053 ILC7054 ILC7055 ILC7056 ILC7057 ILC7058 ILC7059	Project Management Finance Management Entrepreneurship Development and Management Human Resource Management Professional Ethics and CSR Research Methodology IPR and Patenting Digital Business Management Environmental Management

 # Common with all branches

SEMESTER VII

EXAMINATION SCHEME

Course Code	Course Name	CA Marks			ESE		TW / O / P Marks				Total Marks
		T1	T2	T = T1 + T2	Marks	Duration (in Hrs)	TW	O	P	P&O	
EXC701	Microwave Engineering	20	20	40	60	2.5	-	-	-	-	100
EXC702	Mobile Communication Systems	20	20	40	60	2.5	-	-	-	-	100
EXDLC703	Major / Professional Elective - Department-level Course – III	20	20	40	60	2.5	-	-	-	-	100
EXDLC704	Major / Professional Elective - Department-level Course – IV	20	20	40	60	2.5	-	-	-	-	100
ILC705	Open Elective - Institute-level Course – II	20	20	40	60	2.5	-	-	-	-	100
EXL701	Microwave Engineering Laboratory	-	-	-	-	-	25	-	-	25	50
EXL702	Mobile Communication Systems Laboratory	-	-	-	-	-	25	-	-	25	50
DLL704	Major / Professional Elective - Department-level Course – IV Laboratory	-	-	-	-	-	25	-	-	25	50
EXPR75	Community Engagement PBL - Innovation-Based Major Project - B	-	-	-	-	-	50	-	-	100	150
Total		**100**	**100**	**200**	**300**	**-**	**150**	**-**	**-**	**175**	**800**

Course Code	Course Name	Credits (TH+P+TUT)
EXC701	**Microwave Engineering**	**3+0+0**
Prerequisite:	1. Electromagnetics and Antenna 2. Principles of Communication Engineering	
Course Objectives:	1. To learn the fundamentals of microwave systems. 2. To learn to make system level design decisions. 3. To learn passive and active device characteristics. 4. To learn the applications of microwaves.	
Course Outcomes:	At the end of the course students will be able to 1. Explain the basic concepts of Microwave Engineering. 2. Analyze microwave transmission lines and matching techniques. 3. Analyze microwave passive components and semiconductor devices. 4. Classify the microwave tubes. 5. Measure microwave parameters. 6. Explain the applications of microwaves in day to day life.	

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
i. Prerequisites and Course Outlines	Prerequisite Concepts and Course Introduction	-	02	**02**
1. Introduction to Microwaves	1.1 Microwave Frequency and Band designation, Characteristics, Advantages, disadvantages and Applications of Microwaves and its hazards.	1 & 2	01	**08**
	1.2 Scattering parameters: Characteristics and Properties.		01	
	1.3 Planar transmission lines: Strip lines, Microstrip lines and coupled lines: Analysis and design. (Numerical)		01	
	1.4 Impedance Matching Network design using Reactive Elements, Single and Double stub matching. (Numerical)		05	
2. Waveguides and Passive Devices	2.1 Types of waveguide: Rectangular and circular waveguides: Construction, Working, Field Equations and modes of TE and TM wave. (Numerical)	2 & 3	04	**08**
	2.2 Resonators, Re-entrant cavities, Tees (E, H and Magic), Hybrid ring, Directional couplers, Phase shifters, Terminations, Attenuators and Ferrite devices such as Isolators, Gyrators, and Circulators.		04	
3. Microwave Tubes	3.1 Microwave linear beam tubes (O type): Limitations of conventional tubes at microwave frequencies;	4	04	**07**

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
	Two Cavity Klystron: Velocity modulation process, bunching process, output power and beam loading. Reflex Klystron: Velocity modulation, power output and efficiency. Helix Traveling Wave tube: Slow wave structures, amplification process, modes of operation of TWT			
	3.2 Microwave cross field tubes (M type): Introduction of cross field devices. Magnetrons: Different types, 8-cavity cylindrical travelling wave Magnetron, Hull cut-off and Hartree conditions, modes of resonance and PI-mode operation Backward wave oscillator		03	
4. Microwave Semiconductor Devices	Microwave solid-state devices: Transferred electron devices Gunn- effect diodes, RWH theory, modes of operations, Avalanche transit time devices: IMPATT diode, TRAPATT diode, BARITT diode	3	06	**06**
5. Microwave Measurements	Description of microwave bench: Different blocks and their features, precautions Microwave power measurement for low medium and high microwave power Measurement of attenuation; Frequency standing wave measurements: measurement of low and high VSWR; Cavity Q; Impedance measurements.	5	05	**05**
6. Microwave Applications	6.1 Industrial application of microwaves: Microwave heating, Industrial control and measurements e.g. thickness measurement and moisture content measurements and medical applications e.g. diathermy and hyperthermia	1 & 6	01	**05**
	6.2 Microwave Radar systems: Basic radar system, radar equation, Introduction of Radar, Radar Parameters and their Classification (Freq., waveform, PRF & application based)- Pulse, CW/FMCW/SFCW, MTI/MST, SAR, Tracking/ Phase Array Radar (Basic Only)		04	
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization.	-	01	**01**
			Total Hrs.	**42**

Books:	
Text Books	1. Samuel Liao, "Microwave Devices and Circuits", Prentice Hall. 2. David Pozar, "Microwave Engineering", Wiley Publication (Fourth Edition). 3. Matthew M. Radmanesh, "Radio Frequency and Microwave Electronic", Pearson Education. 4. Annapurna Das and S. K Das, "Microwave Engineering", McGraw Hill Education (Third Edition). 5. Merill Skolnik, "Introduction to RADAR Systems", Tata McGraw Hill (Third Edition). 6. G.S.N. Raju, "Radar Engineering and Fundamentals of Navigational Aids", Wiley Publication.
Reference Books	1. Colin, "Foundations of Microwave Engineering" Wiley Interscience. (Second Edition) 2. Devendra Mishra, "Radio Frequency and Microwave Communication Circuits- Analysis and Design" John Wiley & Sons. (Second Edition)
Useful Links:	
1. www.nptelvideos.in 2. www.tutorialspoint.com 3. https://onlinecourses.nptel.ac.in/noc19_ee57/preview	

Continuous Assessment (40 Marks):

The distribution of Continuous Assessment marks will be as follows –

1.	Class Test 1 (T-1)	20 marks
2.	Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):

Two class tests of 20 marks each should be conducted in a semester. The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Course Name	Credits (TH+P+TUT)
EXC702	**Mobile Communication Systems**	**3+0+0**

Prerequisite:	1. Digital Communication 2. Computer Communication and Networks
Course Objectives:	1. To understand the cellular fundamentals 2. To understand different types of radio propagation models. 3. To study the system architecture of 2G, 2.5 G and 3G. 4. To develop the concepts of emerging technologies for 4 G standards and beyond.
Course Outcomes:	At the end of the course students will be able to 1. Explain the cellular fundamentals and estimate the coverage and capacity of cellular systems. 2. Classify different types of propagation models and analyse the link budget. 3. Illustrate the fundamentals, system architecture signalling protocol of GSM, 2.5G and IS-95. 4. Apply the concepts of 3G technologies of UMTS and CDMA 2000. 5. Elaborate the principles of 3GPP LTE. 6. Describe the emerging technologies for upcoming mobile communication systems.

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
i. Prerequisites and Course Outlines	Prerequisite Concepts and Course Introduction	-	02	**02**
1. Fundamentals of Mobile Communication	1.1 Introduction to wireless communication: Mobile radio telephony, Examples of Wireless Communication Systems, Related design problems, 1G to 6G Evolution	1	02	**06**
	1.2 The Cellular Concept System Design Fundamentals: Frequency Reuse, Channel Assignment Strategies, Interference and System Capacity, Trunking and Grade of Service, Improving Coverage and Capacity in Cellular Systems		04	
2. Mobile Radio Propagation	2.1 Large scale fading: Free space propagation model, the three basic propagation mechanisms, reflection, ground reflection (two-ray) model, diffraction, scattering, practical Link budget design using path loss models	2	04	**08**
	2.2 Small scale fading: small scale multipath propagation, parameters of mobile multipath channels, types of small-scale fading, Rayleigh and Rician distributions		04	
3. 2G Technologies	3.1 GSM: GSM Network architecture, GSM signaling protocol architecture, GSM channels, frame structure for GSM, GSM speech coding,	3	04	**07**

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
	authentication and security in GSM, GSM hand-off procedures,			
	3.2 GSM evolution: GPRS and EDGE-architecture, radio specifications, channels.		01	
	3.3 IS-95: Architecture of CDMA system, power control in CDMA system, power control, handoff, rake receiver		02	
4. 3G Technologies	4.1 UMTS: Objectives, standardization and releases, network architecture, air interface specifications, channels, security procedure	4	04	**06**
	4.2 CDMA2000cellular technologies: Forward and Reverse Channels, Handoff and Power Control.		02	
5. 3GPP LTE	5.1 Introduction, system overview: Frequency bands and spectrum flexibility, network structure, protocol structure	5	02	**06**
	5.2 Logical and Physical Channels: Mapping of data onto (logical) sub-channels.		02	
	5.3 Physical layer procedures: Establishing a connection, retransmissions and reliability, scheduling, power control, handover.		02	
6. Advanced techniques for 4G deployment	6.1 Multi-antenna Techniques: Smart antennas, multiple input multiple output systems, Massive MIMO	6	02	**06**
	6.2 Cognitive radio: Architecture, spectrum sensing		02	
	6.3 Introduction to 5G network and technologies used in 5G such as small cell concept, Massive MIMO, Beamforming, NOMA, and mm wave, Device-to-Device Communication (D2D)		02	
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization.	-	01	**01**
		Total Hrs.		**42**

Books:	
Text Books	1. Theodore S. Rappaport —Wireless Communications - Principles and Practice, PEARSON, Second edition 2. T L Singal —Wireless Communications, McGraw Hill Education 3. Andreas F. Molisch — Wireless Communications Wiley India Pvt Ltd., Second Edition 4. Raj Pandya- Mobile and Personal Communication Services and Systems (IEEE Series on Mobile & Digital Communications)
Reference Books	1. Upena Dalal —Wireless and Mobile Communications‖, Oxford University Press. 2. Vijay K. Garg —Wireless Communications and Networking‖, Morgan–Kaufmann series in Networking-Elsevier

Useful Links:

1. MIT Open Courseware
2. https://ocw.mit.edu/courses/electrical-engineering-and-computerscience/6-452-principles-of-wireless-communications-spring-2006/
3. http://nptel.ac.in/courses/117104099/
4. Virtual Lab : http://vlab.co.in/

Continuous Assessment (40 Marks):

The distribution of Continuous Assessment marks will be as follows –

1.	Class Test 1 (T-1)	20 marks
2.	Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):

Two class tests of 20 marks each should be conducted in a semester. The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Course Name	Credits (TH+P+TUT)
EXDLC7031	**Major / Professional Elective – Department-level Course – III** **Natural Language Processing**	3+0+0
Prerequisite:	1. Basic English Grammar 2. Statistical and Probability Theory.	
Course Objectives:	1. To understand natural language processing and apply basic algorithms in this field. 2. To get acquainted with the basic concepts and algorithmic description of the main language levels: morphology, syntax, semantics, and pragmatics. 3. To design and implement various language Models and applications of NLP techniques in real life applications	
Course Outcomes:	1. Explain about the basics of natural language processing. 2. Explore capabilities and limitations of current natural language technologies 3. Build model linguistic phenomena with formal grammars. 4. Apply algorithms for NLP based pragmatics problems 5. Analyze mathematical and linguistic foundations underlying approaches to the various areas in NLP. 6. Apply NLP techniques to design real world NLP applications.	

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
i. Prerequisites and Course Outlines	Prerequisite Concepts and Course Introduction	-	02	**02**
1. Introduction to Natural Language Processing	1.1 Introduction to data and its significance in NLP. History of NLP, levels of NLP. Natural language vs. programming language. LLMs as extended application of NLP.	1	01	**03**
	1.2 Knowledge in language processing, 03 Ambiguity in Natural language, stages in NLP, challenges of NLP, Applications of NLP		02	
2. Word Level Analysis	2.1 Morphologyanalysissurvey of English Morphology, Inflectional morphology & Derivational morphology, Lemmatization, finite automata	2	04	**08**
	2.2 Finite state transducers (FST), Morphological parsing with FST, Lexicon free FST Porter stemmer. N Grams N-gram language model, N-gram for spelling correction		04	
3. Syntax analysis	3.1 Part-Of-Speech tagging (POS) Tag set for English (Penn Treebank), Rule based POS tagging, Stochastic POS tagging, Issues Multiple tags & words, Unknown words. Introduction to CFG, Types of Parsing	3	05	**08**

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
	3.2 Sequence labelling: Hidden Markov Model (HMM), Maximum Entropy, and Conditional Random Field (CRF).		03	
4. Semantic Analysis	4.1 Lexical Semantics, Attachment for fragment of English- sentences, noun phrases, Verb phrases, prepositional phrases, Relations among lexemes & their sense	4	06	**08**
	4.2 Homonymy, Polysemy, Synonymy, Hyponymy, WordNet, Robust Word Sense Disambiguation (WSD), Dictionary based approach, Information extracting and Extracting relationships/relations, Latent semantic analysis		02	
5. Pragmatics	Discourse reference resolution, reference phenomenon, syntactic & semantic constraints on co reference	5	06	**06**
6. Applications of NLP	Machine translation, summarization, sentiment analysis, Named Entity Recognition, Language skill: formally a dialog system or dialog engine, Topic Modeling. Applications of Deep learning and LLMs in industry, education and Health care. Ethics in AI used in NLP.	6	06	**06**
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization.	-	01	**01**
		Total Hrs.		**42**

Books:	
Text Books	1. Daniel Jurafsky, James H. Martin "Speech and Language Processing" Second Edition, Prentice Hall, 2008. 2. 2. Christopher D. Manning and Hinrich Schutze, "Foundations of Statistical Natural Language Processing", MIT Press, 1999 3. Steven Bird, Ewan Klein, "Natural Language Processing with Python", O'Reilly, ISBN-13 978-0596516499, 2009
Reference Books	1. Siddiqui and Tiwary U.S., "Natural Language Processing and Information Retrieval", Oxford University Press (2008). 2. Daniel M Bikel and Inned Zitouni, "Multilingual Natural Language Processing Applications", Pearson, 2013. 3. Alexander Clark (Editor), Chris Fox (Editor), Shalom Lappin Editor) The Handbook of Computational Linguistics and Natural Language Processing. 4. Nie1 J le Roux, Sugnet Lubbe, A step by step Tutorial: An introduction into R application and programming.
Useful Links:	
1. https://wordnetweb.princeton.edu/perl/webwn 2. https://onlinecourses.nptel.ac.in/noc21_cs102/preview 3. Kaggle Databases	

Continuous Assessment (40 Marks):

The distribution of Continuous Assessment marks will be as follows –

Class Test 1 (T-1)	20 marks
Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):

Two class tests of 20 marks each should be conducted in a semester. The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Course Name	Credits (TH+P+TUT)
EXDLC7032	**Major / Professional Elective – Department-level Course – III** **Satellite and Nano Satellite Communication**	**3+0+0**
Prerequisite:	1. Principles of Communication Engineering 2. Digital Communication	
Course Objectives:	3. To understand the basics of satellite communications and different satellite communication orbits. 4. To provide an in-depth understanding of satellite communication system operation, launching techniques, satellite link design and earth station technology. 5. To explain the tools necessary for the calculation of basic parameters in a satellite communication system. 6. To review the state of the art in new research areas such as speech and video coding, satellite networking and satellite personal communications, mobile satellite communication, Laser satellite.	
Course Outcomes:	1. Explain basics of satellite communication, space segment and earth segment. 2. Explain different satellite orbits and orbital parameters. 3. Analyse and design link budget of satellite signal for proper communication. 4. Explain various applications of satellite communications. 5. Explain the basics of the Nano satellite and its design. 6. Compare the Space segment access techniques.	

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
i. Prerequisite and Course outline	Prerequisite Concepts and Course Introduction	-	02	**02**
1. Overview of Satellite Systems, Orbits and Launching	1.1 An overview of space and satellite, Microwave frequency bands, Frequency allocation for satellite communication Polar orbiting satellites, Kepler's First, second and third law, orbital elements, apogee, perigee heights, orbital perturbations (Numerical), effects of a non-spherical earth, atmospheric drag	1	03	**08**
	1.2 Selection of launching site, launch window, zero and non-zero degree latitude launching, sea launch, launch vehicles; satellite launch vehicle (SLV), augmented satellite launch vehicle (ASLV), polar SLV, geostationary satellite launch vehicle (GSLV)	1	02	

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
	1.3 Sub-satellite Point, predicting satellite position, Types of orbits: LEO, MEO, GEO, HEO, Sun-synchronous, Molniya, antenna look angles, polar mount antenna, limits of visibility, near geostationary orbits, earth eclipse of satellite, sun transit outage,	2	03	
2. Space Segment	2.1 Satellite configuration, Transponder sub-system, Antenna sub-system, AOC Sub- system, TT&C Sub-system, power sub-system, Thermal sub-system, Beacon signal and its application, Satellite stabilization	2	05	**06**
	2.2 Reliability and quality Assurance	2	01	
3. Earth Station	3.1 General configuration- Block diagram, Antenna system, Feed system, Tracking system, UP/Down Converter, LNA, HPA,	1	02	**04**
	3.2 Optical/laser communication, advantage disadvantage of optical communication, optical ground station	1	01	
	3.3 Introduction of Software defined radio	5	01	
4. Satellite Links	4.1 Isotropic radiated power, transmission losses, free-space transmission, feeder losses, antenna misalignment losses, fixed atmospheric and ionospheric losses, antenna polarization, cross-polarization discrimination, depolarization effects, EIRP, Figure of Merit: G/T, Foot print and link power budget	3	02	**08**
	4.2 System noise, antenna noise, amplifier noise temperature, amplifiers in cascade, noise factor, noise temperature of absorptive networks, overall system noise temperature, carrier to noise ratio	3	02	
	4.3 Uplink: Saturation flux density, input back off, earth station HPA, Downlink: Output back off, satellite TWTA output	3	02	
	4.4 Effects of rain, uplink rain-fade margin, downlink rain-fade margin, combined uplink and downlink C/N ratio, intermodulation noise	3	02	
5. The Space Segment Access and Utilization	5.1 Modulation techniques – ASK, FSK, PSK, BPSK, QPSK, QAM, Space segment access methods, pre- assigned FDMA, demand assigned FDMA, SPADE system, bandwidth-limited and power-limited TWT amplifier operation	6	03	**08**
	5.2 TDMA: Reference Burst; Preamble and Postamble, carrier recovery, network synchronization, unique word detection, traffic date, frame efficiency, channel capacity, preassigned TDMA, demand assigned TDMA, satellite switched TDMA	6	03	

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
	5.3 Code Division Multiple Access: Direct-sequence spread spectrum–acquisition and tracking, spectrum spreading and despreading – CDMA throughput	6	02	
6. Nano Satellite	6.1 The evolution of nano satellite, Nano satellite structure. Microsatellites, Nano satellites, Pico satellites (CubeSats), Femto Satellites, Nano-satellite subsystems: structure, power (EPS), OBC, communication (COMS), Nano-satellite communication protocols (AX.25, CSP); nano-satellite structures (skin frame, truss, monocoque cylinder, skin stringer), structural materials	5	02	**05**
	6.2 Areas of Application: Military, Commercial, Civilian, Educational, Experimental Notable Missions and Trends Small satellite mega-constellations: Starlink, OneWeb, Kuiper, Guowang InSight Mission- MarCO CubeSats, CubeSat Launch Initiative (NASA), Artemis1, Artemis 2, KiboCUBE, Nanosatellite Launch System (NLS), QB50, StudSat, Q-SAT, CubeSat architecture (1U, 3U, 6U)	4	03	
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization.	**-**	01	**01**
		Total Hrs.		**42**

Books:	
Text Books	1. Dennis Roddy, "Satellite Communications", 4th Ed., Mc. Graw-Hill International Ed. 2009 2. Gerard Maral, "VSAT Networks", John Willy & Sons 3. Timothy Pratt, Charles Bostian, and Jeremy Allmuti, "Satellite Communications", John Willy & Sons (Asia) Pvt. Ltd. 2004 4. Wilbur L. Pritchard, Henri G. Suyderehoud, and Robert A. Nelson, "Satellite Communication Systems Engineering", Pearson Publication. 5. Planet Aerospace India "Quintessence of Nano-Satellite Technology", Notion Press
Reference Books	1. M. Richharia, "Satellite Communication Systems Design Principles", Macmillan Press Ltd. Second Edition 2003 2. R. N. Mutangi, "Satellite Communication", Oxford University Press, 2016. 3. Gerard Maral and Michel Bousquet, "Satellite Communication Systems", 4th Edition Wiley Publication, TMH (2009)
Useful Links:	
1. https://nptel.ac.in/courses/117/105/117105131/ 2. https://www.udemy.com/course/nep-certification/	

Continuous Assessment (40 Marks):
The distribution of Continuous Assessment marks will be as follows –

Class Test 1 (T-1)	20 marks
Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):
Two class tests of 20 marks each should be conducted in a semester. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing.

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Course Name	Credits (TH+P+TUT)
EXDLC7033	Major / Professional Elective - Department-level Course – III **Embedded Systems and RTOS**	**3+0+0**

Prerequisite:	1. Microcontrollers 2. Digital Communication 3. Digital Logic Design 4. Sensor Technology
Course Objectives:	1. To develop background knowledge on Embedded Systems. 2. To understand communication techniques used in embedded systems 3. To understand the embedded product development life cycle 4. To write programs for embedded systems and real time operating systems
Course Outcomes:	1. Explain the fundamentals, characteristics, classifications, and real-time requirements of embedded systems. 2. Identify appropriate hardware platform for an Embedded application 3. Select suitable communication protocols and interfaces such as CAN, I²C, SPI, USB, Bluetooth, and Wi-Fi for embedded applications. 4. Discuss synchronization issues, device driver requirements, and RTOS selection criteria for reliable embedded system design. 5. Discuss RTOS concepts including task management, scheduling, synchronization, and inter-process communication for real-time embedded systems. 6. Design an embedded system using Embedded Product Development Life Cycle concepts

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
i. Prerequisite and Course outline	Prerequisite Concepts and Course Introduction	-	02	**02**
1. Introduction	1.1. Definition of Embedded System, Embedded Systems Vs General Computing Systems, Classification, Major Application Areas	1	02	**04**
	1.2. Characteristics and quality attributes (Design Metric) of embedded systems. Real time system‘s requirements, real time issues, interrupt latency	1	02	
2. Embedded Hardware Elements	2.1 Features of Embedded cores- µC, ASIC, ASSP, SoC, FPGA.	2	01	**06**
	2.2 ARM Cortex-M3 Features, Architecture, Programmer’s model, Special Registers, Operating Modes and States, MPU, Memory map and NVIC.	2	05	
3. Communication	3.1 CAN bus, I2C, MOD bus, SPI, RS -485, USB, RS-232	3	05	**07**
	3.2 Wi-Fi, Bluetooth	3	02	
4. Real Time Operating Systems (RTOS)	4.1 Operating system basics, Types of OS	5	01	**07**
	4.2 Task, Process, Thread	4, 5	02	
	4.3 Multiprocessing and Multitasking	4, 5	01	
	4.4 Task scheduling, Schedulability	4	02	
	4.5 Threads, Process , Scheduling :- Putting them all together	5	01	

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
5. RTOS-Synchronization	5.1 Task communications: Pipes, Memory Mapped Object, Message queues, Mailbox, Signaling/ Task Notification, Remote Procedure Call and Socket	4, 5	03	**08**
	5.2 Synchronization Problems: Racing, Deadlock, Livelock, Starvation, Dining Philosopher's problem, Producer-Consumer problem, Reader-Writer problem, Priority Inversion, etc.	3, 4	02	
	5.3 Task synchronization Techniques: Mutex, Semaphore, etc.	3, 4	02	
	5.4 Device drivers	5	01	
	5.5 How to choose RTOS	6		
6. Design of Embedded applications and case studies	6.1 Program Modelling Concepts: DFG, CDFG, FSM, UML	6	02	**07**
	6.2 Embedded Product development life cycle	6		
	6.3 Testing & Debugging: Hardware testing tools, Boundary-scan/JTAG interface concepts, Emulator. Software Testing tools, Simulator, Debugger. White-Box and Black-Box testing	6	02	
	6.4 Case Study: a. Automatic Chocolate Vending Machine b. Digital Camera c. Anti-lock Braking System (ABS)	6	03	
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization**.**	-	01	**01**
			Total Hrs.	**42**

Books:	
Text Books	1. Introduction to Embedded Systems 2nd edition Shibu K.V Mc Graw Hill 2009 2. Embedded System Design: A unified Hardware/Software Introduction Frank Vahid and Tony Givargis Wiley Publication 1999 3. The definitive guide to the ARM Cortex-M3 2nd edition Jospeh Yiu Elesevier 2010
Reference Books	1. Embedded Real Time Systems: Concepts, Design & Programming Second edition K.V.K.K. Prasad Dreamtech Publication 2003 2. Embedded systems software primer First edition David Simon Pearson 2002 3. Embedded real systems Programming First edition Iyer, Gupta Tata MCgraw- Hill Publication 2010 4. Embedded Systems Architecture, Programming and design 3rd edition Raj Kamal Tata MCgraw- Hill Publication 2017
Useful Links	1. https://nptel.ac.in/courses/106105193 2. https://nptel.ac.in/courses/106105172 3. https://nptel.ac.in/courses/108105057

Continuous Assessment (40 Marks):
The distribution of Continuous Assessment marks will be as follows –

Class Test 1 (T-1)	20 marks
Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):
Two class tests of 20 marks each should be conducted in a semester. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing.

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Course Name	Credits (TH+P+TUT)
EXDLC7034	Major / Professional Elective – Department-level Course – III **Big Data Analytics**	3-0-0
Prerequisite:	1. Java programming 2. Basics of SQL 3. Probability 4. Data mining and machine learning methods	
Course Objectives:	1. To provide an overview of an exciting growing field of big data analytics. 2. To introduce programming skills to build simple solutions using big data technologies such as MapReduce and scripting for NoSQL, and the ability to write parallel algorithms for multiprocessor execution. 3. To enable students to have skills that will help them to solve complex real world problems in for decision support. 4.	
Course Outcomes:	**After successful completion of this course, learner will be able to:** 1. Describe the basic concepts of big data and Hadoop Framework. 2. Use various distributed storage system and NoSQL databases to collect, manage, store, query and analyze big data. 3. Apply scalable algorithms based on Hadoop to perform big data analytics. 4. Apply scalable algorithms for analyzing stream data. 5. Interpret Complex real-world problems in various applications like recommender systems, social media applications, page ranking. 6. Develop basic Spark applications using RDDs and DataFrames.	

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
i. Prerequisite and Course outline	**Prerequisite Concepts and Course Introduction**	**-**	02	**02**
1. Introduction	1.1 Introduction to Big Data, Big Data characteristics, Types of Big Data, Traditional vs. Big Data business approach, Case Study of Big Data Solutions	1	02	**07**
	1.2 Introduction to Hadoop: Concept of Hadoop, Hadoop Core Components, Hadoop Ecosystem, Hadoop limitations		03	
	1.3 Pig Architecture, User-defined functions—Working with scripts. Introduction-Hive modules, Data types and file formats, Hive scripts.		02	
2. Storage system HDFS and NOSQL	2.1 Distributed File Systems: Physical Organization of Compute Nodes, Large Scale File-System Organization.	2	02	**07**
	2.2 NoSQL: Introduction to NoSQL, NoSQL Business Drivers, NoSQL Data Architecture Patterns: Key-value stores, Graph stores, Column family (Bigtable) stores, Document stores, Variations of NoSQL architectural patterns, NoSQL Case		05	

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
	Study, NoSQL solution for big data, Understanding the types of big data problems, Analyzing big data with a shared-nothing architecture, Choosing distribution models: master-slave versus peer-to-peer, NoSQL systems to handle big data problems. CAP theorem.			
3. Batch Processing	3.1 MapReduce: The Map Tasks, Grouping by Key, The Reduce Tasks, Combiners, Details of MapReduce, Execution, Coping With Node Failures.	3	03	**07**
	3.2 Algorithms Using MapReduce: Matrix-Vector multiplication by MapReduce, Relational-Algebra Operations, Computing Selections by MapReduce, Computing Projections by MapReduce , Union, Intersection, and Difference by MapReduce, Computing Natural Join by MapReduce, Grouping and Aggregation by MapReduce Matrix - Matrix Multiplication using MapReduce, Limitations of MapReduce		04	
4. Stream Processing	4.1 The Stream Data Model: A Data-Stream-Management System, Examples of Stream Sources, Stream Queries, Issues in Stream Processing	4	01	**07**
	4.2 Sampling Data techniques in a Stream, Filtering Streams: Bloom Filter with Analysis.		01	
	4.3 Counting Distinct Elements in a Stream, CountDistinct Problem, Flajolet-Martin Algorithm, Combining Estimates, Space Requirements		02	
	4.4 Counting Ones in a Window: The Cost of Exact Counts The Datar-Gionis-Indyk-Motwani Algorithm, Query Answering in the DGIM Algorithm, Decaying Windows.		03	
5. Big Data Applications	5.1 Recommendation Systems: A Model for Recommendation Systems, Content Based Recommendations, Collaborative Filtering, Case study on recommendation systems	5	03	**07**
	5.2 Link Analysis PageRank Overview, Efficient computation of PageRank: PageRank Iteration Using MapReduce, Use of Combiners to Consolidate the Result Vector.		02	
	5.3 Mining Social-Network Graphs Social Networks as Graphs, Clustering of Social-Network Graphs, Direct Discovery of Communities, Case study on social network graphs.		02	
6. Spark Programming Basics	6.1 Overview of Spark – Hadoop Overview of Spark – Hadoop vs. Spark – Cluster Design – Cluster Management – Performance, Application Programming Interface (API): Spark Context, Resilient Distributed Datasets, Creating RDD, RDD Operations, and Saving RDD – Lazy Operation – Spark Jobs.	6	05	**07**
	6.2 SQL Context – Importing and Saving data – Data frames – using SQL		02	
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization**.**	-	01	01
			Total Hrs.	**42**

Books:	
Text Books	1. Alex Holmes “Hadoop in Practice”, Manning Press, Dreamtech Press. 2. Anand Rajaraman and Jeff Ullman “Mining of Massive Datasets”, Cambridge University Press. 3. Dan McCreary and Ann Kelly “Making Sense of NoSQL” – A guide for managers and the rest of us, Manning Press 4. Jean-Georges Perrin, Foreword by Rob Thomas, “Spark in Action”, Second Edition, Manning Press
Reference Books	1. Tom White “Hadoop: The Definitive Guide”, O'Reilly Media, Inc., June 2009 2. Bill Franks “Taming the Big Data Tidal Wave: Finding Opportunities In Huge Data Streams With Advanced Analytics”, 3. Wiley Chuck Lam, “Hadoop in Action”, Dreamtech Press3. Jared Dean, “Big Data, Data Mining and Machine Learning: Value Creation for Business Leaders and Practitioners”, Wiley India Private Limited, 2014. 4. Jiawei Han and Micheline Kamber, “Data Mining: Concepts and Techniques”, Morgan Kaufmann Publishers, 3rd ed, 2010. 5. Lior Rokach and Oded Maimon, “Data Mining and Knowledge Discovery Handbook”, Springer 2nd Edition, 2010 6. Ronen Feldman and James Sanger, “The Text Mining Handbook: Advanced Approaches in Analyzing Unstructured Data”, Cambridge University Press, 2006
Useful Links:	
1. https://hadoop.apache.org 2. https://hadoop.apache.org/docs/r2.8.0/hadoop-project-dist/hadoop-common/core-default.xml 3. Apache Hive 4. Welcome to Apache Pig!	

Continuous Assessment (40 Marks):

The distribution of Continuous Assessment marks will be as follows –

1.	Class Test 1 (T-1)	20 marks
2.	Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):

Two class tests of 20 marks each should be conducted in a semester. The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Course Name	Credits (TH+P+TUT)
EXDLC7035	Major / Professional Elective – Department-level Course – III RF Design	3+0+0

Prerequisite	1. Electromagnetics and Antenna 2. Principles of Communication Engineering
Course Objectives	1. To learn RF circuit fundamentals for designing various circuit building blocks in a typical RF transceiver. 2. To learn design of RF amplifier 3. To learn design of RF oscillator 4. To learn importance of RF Mixer/ EMI/ EMC
Course Outcomes	1. Design impedance matching networks and passive RF 2. Design the RF amplifiers. 3. Design the RF oscillators. 4. Differentiate the RF mixers. 5. Analyze EMI and EMC in RF circuits. 6. Analyze stability of RF trans-receiver.

Module No. & Name	Sub Topics	CO mapped	Hrs. / Sub Topic	Total Hrs./ Module
Prerequisite and Course outline	Prerequisite Concepts and Course Introduction	-	02	**02**
1. RF Filter Design	1.1 Filter design using Image parameter method	1	02	**08**
	1.2 Filter design using Insertion loss method- Introduction and basic principle Maximally flat low pass prototype, Equal ripple low pass prototype		04	
	1.3 Filter Transformations: Frequency transformations, Richards Transformation, Kuroda's Identities.		02	
2. RF Amplifier Design	2.1 Two-port power gain derivation, signal flow graph (SFG) and stability criterion	2 & 6	02	**10**
	2.2 Single stage amplifier design: Design for maximum gain, design for specified gain, low noise amplifier design		06	
	2.3 Introduction to Power amplifier: Characteristics of power amplifier and classes of amplifiers		01	
	2.4 Emerging Trends in RF Design**:** RFIC design flow, on-chip passive components, CMOS RF technology, RFIC applications (5G, Wi-Fi, Bluetooth, IoT), and introductory HFSS simulation of on-chip passive structures/interconnects.		01	
3. RF Oscillator	3.1 One-port RF oscillator design.	3 & 6	02	**06**
	3.2 Two-port RF oscillator design		04	
4. RF Mixer	Mixers: Characteristics, Various types of Mixers: Single ended diode mixers, FET mixers, Balanced mixers, Image reject mixers and other types of mixers.	4	05	**05**

Module No. & Name	Sub Topics	CO mapped	Hrs. / Sub Topic	Total Hrs./ Module
5. Electromagnetic Interference in RF circuits	5.1 Introduction. Natural and Nuclear Sources of EMI, EMI from Apparatus and Circuits. Quantification of Communication System EMI.	5	01	**05**
	5.2 Elements of Interference, Including Antennas, Transmitters, Receivers and Propagation. Electronic Equipment and System EMI Concepts. Examples of EMI Coupling Modes.		01	
	5.3 Mode of coupling: Common-Mode coupling, Differential mode coupling, and other coupling mechanisms (Power supply and victim amplifiers)		02	
6. Electromagnetic Compatibility	6.1 For Achieving EMC: Grounding, Bonding, Shielding Effectiveness, EMI Diagnostics and Fixes: Techniques used in EMI Diagnostics Fixes, troubleshooting.	5	01	**05**
	6.2 Instruments, Tools, used to measure Electromagnetic Field (Radiated and Conducted Emission): - voltage and current probe, LISN, CDN, Clamp, Field probes, Spectrum analyzer, Oscilloscope, EMI Receiver.		02	
	6.3 Electromagnetic Noise specification: - Surge, EFT (Electrical Fast transients), PFMF, Radiated and conducted susceptibility, Voltage and dips interruption, Ring wave, Damped oscillatory wave.		01	
	6.4 EMC Specifications, Standards and Measurements. A Discussion of the Genesis of EMC documentation including a historical Summary, The Rationale, and A Review of MIL-Std., FCC And CISPR Requirements.		01	
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization.	-	01	**01**
		Total Hrs.		**42**

Books:	
Text Books	1. David M. Pozar, *Microwave Engineering*, 4th Edition, Wiley, 2011. 2. Reinhold Ludwig and Gene Bogdanov, *RF Circuit Design: Theory and Applications*, 2nd Edition, Pearson/Prentice Hall, 2009. 3. W. Prasad Kodali, *Engineering Electromagnetic Compatibility: Principles, Measurements, Technologies, and Computer Models*, 2nd Edition, Wiley-IEEE Press, 2001. 4. David A. Weston, *Electromagnetic Compatibility: Methods, Analysis, Circuits, and Measurement*, 3rd Edition, CRC Press, 2017. *(Recommended updated replacement for the earlier title Electromagnetic Compatibility: Principles and Applications, 2nd Edition, 2001.)* 5. Mark I. Montrose and Edward M. Nakauchi, *Testing for EMC Compliance: Approaches and Techniques*, 2nd Edition, Wiley-IEEE Press, 2004.
Reference Books	1. Guillermo Gonzalez, *Microwave Transistor Amplifiers: Analysis and Design*, 2nd Edition, Prentice Hall, 1997. 2. Clayton R. Paul, *Introduction to Electromagnetic Compatibility*, 2nd Edition, John Wiley & Sons, 2006.

Useful Links:

1. www.nptelvideos.in
2. https://nptel.ac.in/courses/108/106/108106138/
3. https://freevideolectures.com/course/4367/nptel-microwave-theory-techniques

Continuous Assessment (40 Marks):

The distribution of Continuous Assessment marks will be as follows –

Class Test 1 (T-1)	20 marks
Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):

Two class tests of 20 marks each should be conducted in a semester. The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Course Name	Credits (TH+P+TUT)
EXDLC7041	**Major / Professional Elective – Department-level Course – IV** **Neural Networks and Deep Learning**	**3 + 0 + 0**
Prerequisite	Machine Learning	
Course Objectives	1. To understand the fundamentals of neural networks 2. To learn advanced topics such as recurrent neural networks, long short term memory cells and convolutional neural network 3. To understand tuning of the parameters of neural networks. 4. To learn applications of neural networks in real-world problem	
Course Outcomes:	1. Explain the basic concepts of perceptron. 2. Mathematically illustrate forward and back propagation in Neural Networks. 3. Use optimization models to overcome the limitations in Neural Networks. 4. Tune the parameters of Neural Networks. 5. Implement Deep Learning algorithm to the given dataset. 6. Describe the applications of the Neural Networks.	

Module No. & Name	Sub Topics	CO Mapped	Hrs. / Sub Topic	Total Hrs. / Module
i. Prerequisite and Course outline	Prerequisite Concepts and Course Introduction	-	02	**02**
1. Perceptron	Overview of Deep Learning Biological Neuron, Idea of computational units, McCulloch–Pitts unit and Thresholding logic, Linear Perceptron, Perceptron Learning Algorithm, Linear separability, Convergence theorem for Perceptron Learning Algorithm.	1	03	**03**
2. Neural Network	2.1 One hidden layer Neural Network-Output, Vectorization, - Activation functions: types and comparison - Loss functions: Mean square loss, cross entropy loss - Optimizers: Gradient Descent Algorithm - Back propagation	2	05	**06**
	2.2 Random Initialization, Regularization, Learning rate Why Neural Network didn't take off?		01	

Module No. & Name	Sub Topics	CO Mapped	Hrs. / Sub Topic	Total Hrs. / Module
3. Better Training of Neural Networks	3.1 Over fitting, Under fitting, bias and variance - Vanishing gradients, exploding gradients - Second order methods for training - Saddle point problem in Neural Network	3	02	**05**
	3.2 Regularization methods (dropout, drop connect, batch normalization)		01	
	3.3 Newer optimization methods for neural networks (SDG, rmsprop, adam)		02	
4. Deep Neural Network	4.1 Forward propagation, Vectorised implementation, Backward propagation (2 hidden layers- introduction)	2, 4	03	**06**
	4.2 Hyper parameters - Difficulty of training deep neural networks: Vanishing gradients, exploding gradients, etc. - Greedy layerwise training		03	
5. Convolutional Neural Networks	- Convolution filters - Pooling - FC layers - Hyper parameters - LeNet - AlexNet. - VGG - ResNet	5	08	**08**
6. Recurrent Neural Networks and Applications	6.1 Recurrent Neural Networks Back propagation through time - Why RNN? (Vanishing Gradient) - Types of RNN (Single input single output, etc.) - Long Short Term Memory - RNN using LSTM - Bidirectional LSTMs - Introduction to Transformers and attention	5	06	**11**
	6.2 Applications of Neural Networks Applications in Healthcare, Marketing, Education, Business - Computer Vision - NLP - Speech	6	05	
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization.	-	01	**01**
			Total Hrs.	**42**

Books:	
Text Books	1. Deep Learning, Ian Goodfellow and Yoshua Bengio and Aaron Courville, MIT Press, 2016 2. Deep Learning Tutorial, LISA Lab, University of Montreal 3. Deep Learning: Methods and Applications By Li Deng and Dong Yu 4. Neural Networks and Deep Learning By Michael Nielsen
Reference Books	1. Neural Networks: A Systematic Introduction, Raúl Rojas, 1996 2. Pattern Recognition and Machine Learning, Christopher Bishop, 2007

Useful Links:

1. https://www.deeplearningbook.org/
2. http://deeplearning.net/tutorial/deeplearning.pdf
3. https://www.microsoft.com/en-us/research/wp-content/uploads/2016/02/DeepLearning-NowPublishing-Vol7-SIG-039.pdf
4. https://ee541.cankaya.edu.tr/course.php?page=Syllabus
5. https://d2l.ai/index.html
6. https://research.google.com/colaboratory/

Continuous Assessment (40 Marks):

The distribution of Continuous Assessment marks will be as follows –

Class Test 1 (T-1)	20 Marks
Class Test 2 (T-2)	20 Marks

Two class tests of 20 marks each should be conducted in a semester. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing.

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Course Name	Credits (TH+P+TUT)
EXDLC7042	**Major / Professional Elective – Department-level Course – IV** **Wireless Networks**	3+0+0

Prerequisite	Computer Communication Networks
Course Objectives	1. To Understand Basics of Wireless Networks 2. To Know different IEEE standards like IEEE 802.15, IEEE 802.11, IEEE 802.16 3. To develop the concept of Wireless Adhoc Networks and Sensor networks. 4. To understand Wireless sensor networks, mesh networks and IoT
Couse Outcomes	1. Explain the fundamentals, architecture, design issues and standards of wireless networks and Body area networks. 2. Discuss the specifications, architectures, protocol stack, security procedures of personal area network (PAN) technologies such as Zigbee, Bluetooth, UWB, RFID, NFC etc. 3. Classify different Wireless Local Area Networks based on their Architecture, Radio specifications, Protocol Stack, Security procedures. 4. Illustrate the fundamentals and architecture of wireless Metropolitan Area Networks (WMAN) and describe the phases of planning and design of wireless networks with link budgets 5. Describe the basic architecture, Protocol Stack and working of Wireless Ad hoc Networks. 6. Describe the basic architecture, Protocol Stack and working of Wireless Sensor networks, Ad hoc Networks and IOT

Module No & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
i. Prerequisite and Course outline	Prerequisite Concepts and Course Introduction	-	02	**02**
1. Basics of Wireless Networks	1.1 Wireless network architecture, currently working Classifications, switching technology, communication problems	1	03	**04**
	1.2 Wireless body area networks: Properties Network architecture Network components Applications		01	
2. Wireless Personal Area Networks	2.1 WPAN: Bluetooth (IEEE802.15.1): Radio specifications protocol stack link types security state model Error correction topologies application, Bluetooth 5.4, Bluetooth LE Audio	1	04	**08**
	2.2 ZigBee (IEEE 802.15.4):	2	02	

Module No & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
	Radio specifications components topologies protocol stack applications			
	2.3 RFID: Radio specifications architecture and types		02	
	2.4 Near field communication & UWB (IEEE 802.15.3a): Introduction and working	02	02	
3. Wireless Local Area Network	3.1 Equipment Technologies Topologies Applications IEEE 802.11 WLAN	3	02	**08**
	3.2 Joining an existing basic service set Security and Power management		02	
	3.3 Main features of IEEE 802.11 a /b /g / n/ ac/ ax		02	
	3.4 WiFi /6E, WiFi 7 Multi Link Operation (MLO)		02	
4. Wireless Metropolitan and Wide Area Networks	4.1 WMAN(IEEE820.16): Introduction WMAN network architecture Network protocols Broadband wireless networks application	4	02	**07**
	4.2 WWAN: Planning and design of Wireless network: radio link and Coverage planning		02	
	4.3 Link budgets for GSM, CDMA, CDMA 2000, HSDPA Systems		03	
5. Wireless Ad-hoc networks	5.1 Wireless Ad hoc Networks: Features, advantages & applications	5	02	**06**
	5.2 Mobile Ad hoc Networks: (MANETs)Network Architecture, MAC protocols, UAV (Drone) Networks		02	
	5.3 Vehicular Ad hoc Networks: (VANETs): Characteristics, Protocols and Applications, Connected Autonomous Vehicles (C-V2X)		02	
6. Wireless Sensor Networks	6.1 Wireless Sensor Networks: Network architecture, Protocols, technologies, and applications	6	02	**06**
	6.2 Wireless Mesh Networks: Network architecture, Protocols, technologies, Applications		02	
	6.3 Internet of Things: Framework, Architecture, Technology, and examples, M2M communication		02	
	6.4 Artificial Intelligence for Wireless Networks, Green Wireless Networks		02	
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization	-	01	01
			Total Hrs.	**42**

Books:	
Text Books	1. Vijay K. Garg," Wireless Communication and networking", Morgan-Kaufmann Series in Networking-Elsevier 2. Dr. Sunil Kumar S. Manvi, Mahabaleshwar S. Kakkasageri, "Wireless & Mobile Networks: Concepts and Protocols" Wiley India.
Reference Books	1. Kazem Sohrby, Daniel Minoli and Taieb Znati," Wireless Sensor Networks: Technology, Protocols, and Applications", Wiley Student Edition 2. Raj Kamal," Internet of Things Architecture & Design Principles
Reference Papers	1. E. S. Pramukantoro and A. Gofuku, "A study of Bluetooth Low Energy (BLE) Frameworks on the IoT based Heart Monitoring System," *2021 IEEE 3rd Global Conference on Life Sciences and Technologies (LifeTech)*, Nara, Japan, 2021, pp. 108-110, doi: 10.1109/ LifeTech52111.2021.9391777.Mahapatra, Rajarshi, et al. "Energy efficiency tradeoff mechanism towards wireless green communication: A survey." IEEE Communications Surveys & Tutorials 18.1 (2015): 686-705. 2. Gugulothu, Sravan Kumar, and Madhu Ramarakula. "Green wireless communication." Wireless Personal Communications 141.1 (2025): 277-311
Useful Links:	
1. https://zigbeealliance.org/solution/zigbee/ 2. https://www.bluetooth.com/ 3. https://www.ieee802.org/ 4. https://www.wi-fi.org/discover-wi-fi/wi-fi-certified-6 5. https://iot-now.com/2024/04/04/143489-iot-devices-wi-fi-6e-and-the-future-of-wi-fi-7/	

Continuous Assessment (40 Marks):
The distribution of Continuous Assessment marks will be as follows –

Class Test 1 (T-1)	20 marks
Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):
Two class tests of 20 marks each should be conducted in a semester. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing.

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Course Name	Credits (TH+P+TUT)
EXDLC7043	**Major / Professional Elective – Department-level Course – IV** **Autonomous Vehicle**	3 + 0 + 0
Prerequisite:	1. Microcontrollers 2. Communication Engineering fundamental 3. Control System	
Course Objectives:	1. To develop an understanding of the integrated architecture of autonomous vehicle systems, including perception, communication, decision-making, and motion planning modules. 2. To enable students to analyze real-world autonomous driving scenarios by integrating sensory data, vehicle-to-everything (V2X) communication, and environmental constraints. 3. To equip learners with the knowledge of modern computational tools and algorithms for perception and environment understanding, including computer vision and sensor fusion techniques. 4. To train students to design and implement navigation strategies for autonomous vehicles by combining perception outputs, communication inputs, and trajectory planning under realistic constraints.	
Course Outcomes:	1. Explain the integrated architecture and operational principles of autonomous vehicle systems and their components. 2. Analyse autonomous driving scenarios by fusing passive perception data, vehicle communication inputs, and environmental constraints to identify technical and societal challenges. 3. Apply modern computational tools and algorithms for perception and environment understanding, including computer vision and sensor data processing. 4. Design autonomous navigation solutions by integrating perception, localization, planning, and control for safe vehicle operation. 5. Evaluate autonomous vehicle systems with respect to safety, ethical responsibility, and their impact on society, environment, and sustainable mobility. 6. Demonstrate professional competence through effective teamwork, technical communication, and independent learning while implementing and presenting autonomous vehicle–related solutions or case studies.	

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
i. Prerequisite and Course outline	Prerequisite Concepts and Course Introduction	-	02	**02**
1. Introduction to Autonomous Vehicles & components	1.1 Types of Autonomous Vehicle, environment, perception, mapping, planning and control (components)	1,5	01	**04**
	1.2 Self-driving cars, Evolution of autonomous driving (SAE levels), Centralized & zonal E/E		01	

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
	architectures, Software-defined vehicles (SDV)			
	1.3 Functional safety basics (ISO 26262)		01	
	1.4 Introduction to AUTOSAR: layered architecture (BSW / RTE / ASW), AUTOSAR Classic vs Adaptive		01	
2. Automotive Radar Systems	2.1 Basics of radar principles (FMCW radar)	2,3,4	02	**08**
	2.2 Range, velocity, and angle estimation		02	
	2.3 Doppler effect in automotive radar		02	
	2.4 Signal processing in radar: -FFT, CFAR detection, Radar advantages & limitations. Applications: 1) Adaptive cruise control(ACC) 2) Collision avoidance		02	
3. Perception and Sensor Fusion	3.1 Active and passive sensor, examples of sensors	2,3,5, 6	02	**06**
	3.2 Need for fusion (Radar + Camera + LiDAR)		02	
	3.3 HD maps & localization (GPS + IMU), Environment modelling		02	
4. Computer Vision	4.1 Hardware layers of vision system, Hardware Synchronization, Calibration, open source for calibration, Sensor Fusion. Image formation & camera models	2, 3, 4,6	02	**07**
	4.2 Lane detection, object detection, object tracking		02	
	4.3 basics (CNNs), Semantic segmentation		01	
	4.4 Challenges: Lighting, weather, occlusion. Tools/frameworks: OpenCV , ROS 2		02	
5. Trajectory Planning and Control	5.1 TP&C architecture for AV, Path planning strategies-A*, RRT, PID, MDP	4,5,6	04	**08**
	5.2 Behavioural and motion Planning, Feedback control, PID controller and Auto tuning		04	
6. Automotive Communication, Cyber security Safety, Validation,	6.1 V2X communication, Automotive networks: Shift in Role of CAN bus in Central architecture. CAN protocol layers, CAN message Format	2, 3,5,6	02	**06**
	6.2 Cyber security in vehicles, Safety validation & testing approaches, Ethics & societal impact		02	

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
Ethics & Case Studies	6.3 ASPICE introduction: process of SW development. Case studies: Tesla, Waymo		02	
ii.. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization**.**	-	01	**01**
			Total Hrs.	**42**

Books:	
Text Books	1. Markus Maurer, J. Christian Gerde, Barbara Lenz, Hermann Winner, Autonomous Driving, Autonomous Driving, Springer publication, 2016 2. Xin Bi, Environmental Perception Technology for Unmanned Systems, Springer, 2021
Reference Books	1. Shaoshan Liu, Engineering Autonomous Vehicle and Robots, IEEE press, Wiley, 1st Edition 2020 2. Brooks Roodney, Cambrian Intelligence; The early history of New AI. MIT Press Bostorn, MA

Useful Links:

1. https://academy.qualcomm.com/course-catalog/Fundamentals-Software-Defined-Vehicles
2. AUTOSAR Consortium, AUTOSAR Classic Platform Specifications (latest release) - www.autosar.org
3. Donges E., Automotive Safety Systems - From Driver Assistance to Autonomous Driving, SAE International, 2022. [Updated]
4. AUTOSAR_EXP_LayeredSoftwareArchitecture.pdf
5. https://www.autosar.org/standards/classic-platform/
6. https://vda-qmc.de/wp-content/uploads/2023/12/Automotive-SPICE-PAM-v40.pdfs
7. https://academy.qualcomm.com/course-catalog/Introduction-Snapdragon-Ride
8. Github. Mask R-CNN. https://github.com/matterport/Mask_RCNN
9. Github Baidu Apollo. http://github.com/AppIloAuto/Apollo
10. https://www.swaayatt-robots.com

Continuous Assessment (40 Marks):

The distribution of Continuous Assessment marks will be as follows –

Class Test 1	20 marks
Class Test 2	20 marks

Class Tests (20 Marks):

Two class tests of 20 marks each should be conducted in a semester. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing.

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes

Course Code	Course Name	Credits (TH+P+TUT)
EXDLC7044	**Major / Professional Elective – Department-level Course – IV** **Cloud Computing & Security**	**3 – 0 - 0**
Prerequisite	1. Computer Communication Networks 2. Data Structure & Algorithms	
Course Objectives	1. Understand the fundamentals, characteristics, evolution, and service models of cloud computing, along with cloud service management concepts. 2. Learn virtualization, containerization, and orchestration technologies, and their applications in cloud application deployment. 3. Explore open-source cloud platforms and understand their architecture and key components. 4. Gain knowledge of cloud computing security principles and best practices for building secure cloud environments.	
Course Outcomes	At the End of the course students will be able to 1. Explain the fundamentals, characteristics, and evolution of cloud computing. 2. Describe virtualization concepts and evaluate different virtualization technologies. 3. Analyze various cloud computing service models and their applications. 4. Explain open-source cloud platforms and cloud architecture components. 5. Explain the concepts of containerization and orchestration for cloud-based applications. 6. Apply cloud security mechanisms and best practices to ensure secure and reliable cloud environments.	

Module No & Name		Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
i. Prerequisite and Course outline		Prerequisite Concepts and Course Introduction	-	02	**02**
1. Introduction	1.1	Introduction to Cloud Computing, Cloud Characteristics, Cloud Computing Components, Compare Cloud Computing vs Traditional Computing	1	01	**04**
	1.2	Cloud Deployment model (Cloud types Public, Private, Community, Hybrid)		01	
	1.3	Introduction to Cloud Computing Service Models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), Comparison of SaaS, PaaS & IaaS.		02	
2. Fundamentals	2.1	Introduction to Virtualization, Characteristics of	2	01	**07**

Module No & Name		Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
of Virtualization		Virtualized Environments, Hypervisors: Type I and Type II Hypervisors			
	2.2	Virtualization Techniques: Taxonomy of Virtualization, Full and Para-Virtualization and Partial virtualisation, Hardware-Assisted Virtualization (Intel VT-x / AMD-V), CPU Virtualization, Memory Virtualization, I/O Virtualization, Advantages and Limitations, Virtualization vs Containerization (Docker/Kubernetes).		03	
	2.3	Virtualization Platforms: KVM, Xen, VMware, HyperV		03	
3. Cloud Computing Services	3.1	Introduction to Cloud Service Models and Extended Services: Compute as a Service (CaaS): Introduction to Amazon EC2 (Elastic Compute Cloud), EC2 Instance Types, Auto Scaling, Load Balancing	3	01	**07**
	3.2	Storage as a Service (STaaS): Amazon S3 (Simple Storage Service): Working with Buckets Configuring, Bucket Security and Permissions, Bucket Properties and Management. Amazon, EBS (Elastic Block Store): Working with EBS Volumes, Volume Types and Use Cases. Storage Concepts: Object Storage Vs Block Storage Additional Storage Services: Backup as a Service (BaaS), Disaster Recovery as a Service (DRaaS), Cloud Storage Gateways (CSG)		02	
	3.3	Network as a Service (NaaS): Amazon Virtual Private Cloud (VPC), Subnets (Public and Private), Elastic Network Interfaces (ENI), Internet Gateways, Route Tables, Security Groups, Network Access Control Lists (ACLs) Application services: Simple Notification Service (SNS), Simple Queue Service (SQS), and Simple Email Service (SES).		01	
	3.4	Database as a Service (DBaaS): Amazon RDS (Relational Database Service), Non-Relational (NoSQL) Databases		01	
	3.5	Modern Cloud Services: Container as a Service (CaaS), Function as a Service (FaaS), Serverless Computing, AI as a Service (AIaaS), Edge Computing Services, Network as a Service. (Any		02	

Module No & Name		Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
		one or two cloud service from each section)			
4. Open Source Cloud Platforms Architecture	4.1	Introduction to Open Source Cloud Platforms: OpenStack, Apache CloudStack, Eucalyptus, OpenNebula, Proxmox VE etc	CO4	02	**07**
	4.2	OpenStack: Features of OpenStack, OpenStack Architecture, Core OpenStack Components (Nova, Neutron, Swift, Cinder, Keystone, Glance, Horizon), OpenStack Deployment Models, Advantages and Limitations of OpenStack		03	
	4.3	Infrastructure as Code (IaC) & DevOps / CI-CD Pipelines		01	
	4.3	Introduction to Mobile Cloud Computing		01	
5.Containerization and Orchestration	5.1	Containerization Using Docker: Introduction to Containerization, Virtual Machines vs Containers, Docker Architecture and Components, Docker Images and Containers, Building and Managing Docker Images, Running and Managing Containers, Docker Networking and Storage Basics	CO5	02	**7**
	5.2	Container Orchestration Using Kubernetes: Need for Container Orchestration, Kubernetes Orchestration: Introduction to Kubernetes and its Architecture, Kubernetes Components (Pods, Nodes, Deployments, and Services) Deploying and Managing Applications on Kubernetes, Scaling and High Availability Service Discovery and Load Balancing		03	
	5.3	Modern Cloud Trends & Innovations: Serverless Computing (event-driven architecture), Cloud Automation & Platform Engineering, Green Cloud Computing (energy-efficient data centers), Sustainable cloud computing, Cloud Migration: Moving applications/data to cloud Strategies, Hybrid & Multi-cloud migration strategies, Security considerations during migration.		02	
6. Cloud Computing Security	6.1	Cloud Security Fundamentals: Introduction to Cloud Security, Risks Associated with Cloud Computing, Security Challenges in Cloud	CO6	02	**07**

Module No & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
	Environments, Security Considerations in SaaS, PaaS, and IaaS Models, Zero Trust Security Architecture, Cloud-Native Security Tools and Practices, Security Monitoring, Observability, and Incident Response			
	6.2 Identity and Access Management (IAM): Introduction to IAM, AAA Model: Authentication, Authorization, and Accounting, Single Sign-On (SSO), Multi-Factor Authentication (MFA), Role-Based Access Control (RBAC), Attribute-Based Access Control (ABAC), Privileged Access Management (PAM), Authentication and Authorization Management in Cloud Environments, Amazon Cognito for User Authentication and Authorization		03	
	6.3 Key Management Service (KMS) for Encryption Key Management, Data Protection and Encryption in Cloud Environments		02	
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization**.**	-	01	**01**
		Total Hrs.		**42**

Books:	
Text Books	1. Gautam Shroff, *Enterprise Cloud Computing*, Cambridge University Press, 2010. 2. Ronald Krutz, Russell Dean Vines, *Cloud Security*, Wiley India, 2010. 3. Aditya Patawar, *Getting Started with OwnCloud*, Packt Publishing Ltd, 2013. 4. Tim Mather, *Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance (Theory in Practice)*, Wiley, 2010.
Reference Books	1. Rajkumar Buyya et al., *Cloud Computing: Principles and Paradigms*, Wiley India Edition. 2. Barrie Sosinsky, *Cloud Computing Bible*, Wiley India. 3. Rajkumar Buyya, C. Vecchiola, S. Thamarai Selvi, *Mastering Cloud Computing*, McGraw Hill Publication. 4. Toby Velte, Anthony Velte, Robert Elsenpeter, *Cloud Computing – A Practical Approach*, Tata McGraw Hill. 5. Thomas Erl, Zaigham Mahmood, Ricardo Puttini, *Cloud Computing: Concepts, Technology & Architecture*, Pearson.
Useful Links:	
1. www.openstack.org	

2. https://www.nist.gov/news-events/news/2011/10/final-version-nist-cloud-computing-definition-published
3. https://cloudsecurityalliance.org/

Continuous Assessment (40 Marks):
The distribution of Continuous Assessment marks will be as follows –

1.	Class Test 1 (T-1)	20 marks
2.	Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):
Two class tests of 20 marks each should be conducted in a semester. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing.

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Course Name	Credits (TH+P+TUT)
EXDLC7045	**Major / Professional Elective – Department-level Course – IV** **System On-Chip**	**3 + 0 + 0**
Prerequisite	1. Digital VLSI Design 2. Microprocessors and Microcontrollers 3. Basics of Verilog HDL 4. Project Based Learning	
Course Objectives	1. To introduce modern SoC architectures, design flow, IP-based design, and hardware-software co-design. 2. To explain processor subsystems, embedded software, on-chip communication, memory architecture, and IP integration. 3. To develop understanding of RTL/HLS-based IP design, verification, validation, and FPGA prototyping. 4. To examine physical implementation, low-power design, hardware security, and emerging SoC architectures.	
Course Outcomes	1. Explain modern SoC architectures, design flow, IP-based design, and PPA trade-offs. 2. Describe processor subsystems, embedded software, MMIO, boot flow, and peripheral interfaces. 3. Analyze AMBA interconnects, memory hierarchy, DMA, cache coherency, and IP integration. 4. Design simple SoC IP using RTL/HLS and interpret synthesis, timing, latency, and resource reports. 5. Apply verification, validation, testing, co-simulation, and FPGA-prototyping methods. 6. Evaluate physical implementation, low-power design, security, AI accelerators, and chiplet-based SoCs.	
Common Course-Wide Case Study:	PYNQ-Z2-based smart-camera edge-processing SoC comprising the ARM processing system, DDR memory, AXI interconnect and DMA, and an RTL/HLS-based Sobel edge-detection accelerator. The same case study is progressively developed and analysed at the end of every module.	

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
i. Prerequisite and Course Outline	Prerequisite concepts and course introduction: review of Digital VLSI Design, Verilog HDL, microprocessor-based systems, SoC motivation, and course overview.	-	02	**02**
1. Introduction to Modern SoC and System-Level Design	1.1 SoC Architecture and Design Fundamentals: • SoC definition, evolution, and applications; • Types of SoC architectures; • Design metrics • Challenges in modern SoC design.	1	03	**06**
	1.2 System-Level Design Methodology: • SoC design flow from specification to silicon • IP-based design and reuse • Design abstraction levels—system level, TLM/ESL, RTL, and gate level		02	
	1.3 Common Case Study—Architecture and Requirements: PYNQ-Z2-based smart-camera edge-processing SoC		01	
2. Processor Subsystems and Embedded Software for SoC	2.1 Processor Subsystems: • Processor-centric SoC organization; • ARM and RISC-V overview; • RISC-V base ISA and extension concepts;	2	03	**06**
	2.2 Embedded Software and Processor-Accelerator Interaction: • application boot flow; • bare-metal software, RTOS, and embedded Linux overview; • hardware abstraction layers and device drivers; • processor-accelerator communication, control, and synchronization.		02	
	2.3 Common Case Study—Software Control: Develop the software control flow for the smart-camera		01	
3. SoC Communication and Memory	3.1 On-Chip Communication: • AMBA architecture; • Network-on-Chip introduction; • DMA-based data transfer.	3	04	**07**
	3.2 Memory and IP Integration: • memory hierarch; • address mapping and MMIO; • cache coherency basics; • custom peripheral and hardware-accelerator integration; • IP packaging and IP-XACT; introduction to clock-domain and reset-domain crossing.		02	
	3.3 Common Case Study—Data Movement and Integration for smart camera.		01	
4. SoC IP Design using RTL and High-Level Synthesis	4.1 RTL-Based IP Design: • Review of synthesizable Verilog/SystemVerilog; • Combinational and sequential logic; • FSM and datapath design; • Parameterized IP design;	4	03	**07**

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
	• RTL coding guidelines;			
	4.2 High-Level Synthesis-Based IP Design: • C/C++-based HLS design flow; • HLS optimization concepts; • Interpretation of latency, initiation interval, and resource reports.		03	
	4.3 Common Case Study—Accelerator Development	4	01	
5. SoC Verification, Validation and FPGA Prototyping	5.1 SoC Verification Methodologies: • Verification planning; • SystemVerilog testbench concepts;	5	03	**07**
	5.2 Validation, Testing and FPGA Prototyping: • C/RTL co-simulation and hardware-software co-verification; • FPGA-based SoC prototyping; • Waveform, protocol, and Integrated Logic Analyzer debugging; • JTAG, scan, BIST, and DFT basics; • post-silicon validation overview.		03	
	5.3 Common Case Study—Verification and Prototyping: Debug the complete smart-camera SoC on PYNQ-Z2.		01	
6. Physical Implementation, Low-Power, Security and Emerging SoC Architectures	6.1 Physical Implementation and Low-Power Design: • synthesis • floor planning • placement • clock-tree synthesis	6	03	**06**
	6.2 Security and Emerging Architectures: • secure boot • side-channel attack awareness and hardware Trojan awareness • AI/ML accelerators and heterogeneous SoCs; • chiplet-based SoCs,		02	
	6.3 Common Case Study—Implementation Evaluation and Extension: Evaluate timing closure, resource utilization, estimated power, and security considerations of the smart-camera SoC; discuss its extension from Sobel processing to an AI/ML accelerator and future chiplet-based implementation.		01	
ii. Course Conclusion	Integrated recap of modules and outcomes using the completed PYNQ-Z2 smart-camera edge-processing SoC; applications, industry relevance, and summarization.	-	01	**01**
			Total Hrs.	**42**

Books:	
Text Books	1. Engineering the Complex SoC: Fast, Flexible Design with Configurable Processors, Chris Rowen, Pearson. 2. Computer Organization and Design: The Hardware/Software Interface, RISC-V Edition, David A. Patterson and John L. Hennessy, Morgan Kaufmann. 3. System-on-a-Chip Verification: Methodology and Techniques, Prakash Rashinkar, Peter Paterson and Leena Singh, Kluwer Academic Publishers. 4. High-Level Synthesis: From Algorithm to Digital Circuit, Philippe Coussy and Adam Morawiec, Springer.
Reference Books	1. System-on-a-Chip: Design and Test, Rochit Rajsuman, Artech House. 2. Modern VLSI Design: IP-Based Design, Wayne Wolf, Pearson. 3. Low Power Methodology Manual, Michael Keating, David Flynn, Robert Aitken, Alan Gibbons and Kaijian Shi, Springer. 4. SystemVerilog for Design, Stuart Sutherland, Simon Davidmann and Peter Flake, Springer. 5. VLSI Physical Design Automation: Theory and Practice, Sadiq M. Sait and Habib Youssef, World Scientific.

Useful Links:

1. https://nptel.ac.in/
2. https://riscv.org/
3. https://developer.arm.com/
4. https://www.amd.com/en/products/software/adaptive-socs-and-fpgas/vitis.html
5. https://www.accellera.org/
6. https://theopenroadproject.org/

Continuous Assessment (40 Marks):

The distribution of Continuous Assessment marks will be as follows –

Class Test 1 (T-1)	20 marks
Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):

Two class tests of 20 marks each should be conducted in a semester. The first class test is to be conducted when approximately 40% of the syllabus is completed and the second class test when an additional 40% of the syllabus, excluding the contents covered in Test I, is completed. The duration of each test shall be one hour and fifteen minutes. The average of the two class tests (T-1 and T-2) will be considered for Continuous Assessment.

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Open Elective - Institute-level Course– II	Credits (TH+P+TUT)
ILC7051	Project Management	3 + 0 + 0
Course Objectives:	1. To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques. 2. To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure.	
Course Outcomes:	1. Apply selection criteria and select an appropriate project from different options. 2. Write work breakdown structure for a project and develop a schedule based on it. 3. Identify opportunities and threats to the project and decide an approach to deal with them strategically. 4. Use Earned value technique and determine & predict status of the project. 5. Capture lessons learned during project phases and document them for future reference 6. Inculcate leadership qualities and ethics	

Module No. Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
i. Prerequisite and Course outline	Prerequisite Concepts and Course Introduction	-	02	02
1. Project Management Foundation	Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager. Negotiations and resolving conflicts. Project management in various organization structures. PM knowledge areas as per Project Management Institute (PMI).	1	05	05
2. Initiating Projects	How to get a project started, Selecting projects strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter; Project proposal. Effective project team, Stages of team development & growth (forming, storming, norming & performing), team dynamics.	2	06	06
3. Project Planning and Scheduling	Work Breakdown structure (WBS) and linear responsibility chart, Interface Coordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart. Introduction to Project	3	08	08

Module No. Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
	Management Information System (PMIS)			
4. Planning Projects	Crashing project time, Resource loading and leveling, Goldratt's critical chain, Project Stakeholders and Communication plan. Risk Management in projects: Risk management planning, Risk identification and risk register. Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks	4	06	06
5. Projects	5.1 Executing Projects: Planning, monitoring and controlling the cycle. Information needs and reporting, engaging with all stakeholders of the projects. Team management, communication and project meetings.	5	03	08
	5.2 Monitoring and Controlling Projects: Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep. Project audit.		03	
	5.3 Project Contracting Project procurement management, contracting and outsourcing,		02	
6. Project Leadership and Ethics	6.1 Project Leadership and Ethics: Introduction to project leadership, ethics in projects. Multicultural and virtual projects.	6	03	06
	6.2 Closing the Project: Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process of project termination, completing a final report; doing a lessons learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study.		03	
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization.	-	01	01
			Total Hrs.	**42**

Books:	
Text Books	1. Jack Meredith & Samuel Mantel, Project Management: A managerial approach, Wiley India, 7th Edition 2. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 5th Ed, Project Management Institute PA, USA

Reference Books	1. Gido Clements, Project Management, Cengage Learning. 2. Gopalan, Project Management, , Wiley India 3. Dennis Lock, Project Management, Gower Publishing England, 9th Edition

Useful Links:

1. https://nptel.ac.in/courses/110/104/110104073/
2. https://nptel.ac.in/courses/110/107/110107081/
3. https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-mg30/

Continuous Assessment (40 Marks):
The distribution of Continuous Assessment marks will be as follows –

Class Test 1 (T-1)	20 marks
Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):
Two class tests of 20 marks each should be conducted in a semester. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing.

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Open Elective - Institute-level Course– II	Credits (TH+P+TUT)
ILC7052	Finance Management	3 + 0 + 0
Course Objectives:	1. To Overview of Indian financial system, instruments and market 2. To Understand Basic concepts of value of money, returns and risks, corporate finance working capital and its management 3. To gain Knowledge about sources of finance, capital structure, dividend policy	
Course Outcomes	1. Describe Indian financial system 2. Discuss basic concepts of returns and risks. 3. Use basic concepts of Time value of money. 4. Discuss sources of finance, capital structure, dividend policy 5 Discuss basic concepts of corporate finance 6 Use basic concepts of working capital management	

Module No. Name	Sub- Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
i. Prerequisite and Course outline	Prerequisite Concepts and Course Introduction	-	02	02
1. Overview of Indian Financial System	1.1 Characteristics, Components and Functions of Financial System.	1	01	06
	1.2 Financial Instruments: Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills.		02	
	1.3 Financial Markets: Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market		02	
	1.4 Financial Institutions: Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-Merchant Banks and Stock Exchanges		01	
2. Concepts of Returns and Risks & Time	2.1 Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of	2	03	

Module No. Name	Sub- Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
Value of Money	Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio.			06
	2.2 Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Continuous Compounding and Continuous Discounting.		03	
3. Overview of Corporate Finance and Financial Ratio Analysis	3.1 Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision.	3	03	09
	3.2 Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis.		06	
4. Capital Budgeting and Working Capital Management	4.1 Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value (NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR)	4	05	10
	4.2 Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity's Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities.		05	
5. Sources of Finance & Capital Structure	5.1 Long Term Sources—Equity, Debt, and Hybrids; Mezzanine Finance; Sources of Short-Term Finance—Trade Credit, Bank Finance, Commercial Paper; Project Finance.	5	02	05
	5.2 Factors Affecting an Entity's Capital		03	

Module No. Name	Sub- Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs/ Module
	Structure; Overview of Capital Structure Theories and Approaches— Net Income Approach, Net Operating Income Approach; Traditional Approach, and Modigliani-Miller Approach. Relation between Capital Structure and Corporate Value; Concept of Optimal Capital Structure			
6. Dividend Policy	Meaning and Importance of Dividend Policy; Factors Affecting an Entity's Dividend Decision; Overview of Dividend Policy Theories and Approaches— Gordon's Approach, Walter's Approach, and Modigliani-Miller Approach	6	03	03
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization.	-	01	01
		Total Hrs.		**42**

Books:	
Text Books	1. Fundamentals of Fin Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi. 2. Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
References:	1. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi. 2. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.

Useful Links:

1. https://nptel.ac.in/courses/110/107/110107144/
2. https://nptel.ac.in/courses/110/105/110105031/

Continuous Assessment (40 Marks):
The distribution of Continuous Assessment marks will be as follows –

Class Test 1 (T-1)	20 marks
Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):
Two class tests of 20 marks each should be conducted in a semester. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing.

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Open Elective - Institute-level Course– II	Credits (TH+P+TUT)
ILC7053	**Entrepreneurship Development and Management**	**3 + 0 + 0**
Prerequisites:	Fundamentals of Technology	
Course Objectives:	1. To Acquaint with Entrepreneurship and Management of Business. 2. To understand Indian environment for entrepreneurship. 3. To Ideate EDP, MSME. 4. To discuss the Government Plan for Start-up Business. 5. To analyze the Business Risk. 6. To discuss the Business Life Cycle.	
Course Outcomes:	1. Explain the concept of Business Plan and the Role of Money and Capital Markets in Entrepreneurial Development. 2. Analyze Key regulations and legal aspects of entrepreneurship in India. 3. Explain Government Policies for Start-up. 4. Describe Different Government initiatives for Start-up. 5. Explain Issues and Problems Faced by Micro and Small Enterprises. 6. Describe Growth Strategies for small businesses.	

Module No. & Name	Sub Topics	COs Mapped	Hours/ Sub Topics	Total Hours
i. Prerequisite and Course outline	Prerequisite Concepts and Course Introduction	-	02	**02**
1. Overview Of Entrepreneurship	1.1 Definitions, Roles and Functions/ Values of Entrepreneurship, History of Entrepreneurship Development.	1	01	04
	1.2 Role of Entrepreneurship in the National Economy, Functions of an Entrepreneur.	1	01	
	1.3 Entrepreneurship and Forms of Business Ownership Role of Money and Capital Markets in Entrepreneurial Development: Contribution of Government Agencies in Sourcing information for Entrepreneurship.	1	02	
2. Business Plans and Importance of Capital to Entrepreneurship	2.1 Introduction: Preliminary and Marketing Plans, Management and Personnel.	2	02	09
	2.2 Start-up Costs and Financing as well as Projected Financial Statements, Legal Section, Insurance, Suppliers and Risks, Assumptions and Conclusion, Capital and its Importance to the Entrepreneur.	2	03	
	2.3 Entrepreneurship And Business Development: Starting a New Business, Buying an Existing Business.	2	02	

Module No. & Name	Sub Topics	COs Mapped	Hours/ Sub Topics	Total Hours
	2.4 New Product Development, Business Growth and the Entrepreneur Law and its Relevance to Business Operations.	2	02	
3. Entrepreneurship Development	Women's Entrepreneurship Development, Social Entrepreneurship-Role and Need, EDP Cell, Role of Sustainability and Sustainable Development for SMEs, Case Studies, Exercises.	3	04	04
4. Indian Environment for Entrepreneurship	4.1 Key Regulations and Legal Aspects, MSMED Act 2006 and its Implications, Schemes and Policies of the Ministry of MSME, Role and Responsibilities of various Government Organisations, Departments, Banks etc.	4	03	09
	4.2 Role of State Governments in Terms of Infrastructure Developments and Support etc.	4	04	
	4.3 Public Private Partnerships, National Skill Development Mission, Credit Guarantee Fund, PMEGP, Discussions, Group Exercises etc.	4	02	
5. Effective Management of Business	5.1 Issues and Problems Faced by Micro and Small Enterprises and Effective Management of M and S Enterprises.	5	04	08
	5.2 Risk Management, Credit Availability, Technology Innovation, Supply Chain Management, Linkage with Large Industries, Exercises, E-Marketing.	5	04	
6. Achieving Success in The Small Business	Stages of the Small Business Life Cycle, Four Types of Firm-Level Growth Strategies, Options – Harvesting or Closing Small Business Critical Success Factors of Small Business.	6	05	05
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization.	-	01	01
			Total Hrs.	**42**

Books:	
Text Books:	1. P Charantimath, Entrepreneurship Development- Small Business Enterprise, Pearson 2. R Hisrich and M Peters, Entrepreneurship, McGraw Hill Company. 3. D Kuratko, Entrepreneurship- Principles and Practices, Thomson Publication
Reference Books:	1. Dr T Chhabra, Entrepreneurship Development, Sun India Publications, New Delhi. 2. Law and Practice Relating to Micro, Small and Medium Enterprises, Taxmann Publication Ltd. 3. L Maddhurima, S Shikah, Entrepreneurship, Excel Books. 4. R Bansal ,STAY Hungry STAY Foolish, CIIE, IIM Ahmedabad
Useful Links:	
1. www.msme.gov.in/ 2. www.dcmesme.gov.in/ 3. www.msmetraining.gov.in/	

Continuous Assessment (40 Marks):
The distribution of Continuous Assessment marks will be as follows –

Class Test 1 (T-1)	20 marks
Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):
Two class tests of 20 marks each should be conducted in a semester. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing.

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Open Elective - Institute-level Course– II	Credits (TH+P+TUT)
ILC7054	**Human Resource Management**	**3 + 0 + 0**
Prerequisites:	--	
Course Objectives:	1. To introduce the students with basic concepts, techniques and practices of t human resource management. 2. To provide an opportunity of learning Human resource management (HRM) processes, related with the functions, and challenges in the emerging perspective of today's organizations. 3. To familiarize the students about the latest developments, trends & different aspects of HRM. 4. To acquaint the student with the importance of inter-personal & inter-group behavioural skills in an organizational setting required for future stable engineers, leaders and managers.	
Course Outcomes:	1. Describe the concepts, aspects, techniques and practices of human resource management. 2. Describe the Human resource management (HRM) processes, functions, changes and challenges in today's emerging organizational perspective. 3. Apply the knowledge about the latest developments and trends in HRM. 4. Analyze the knowledge of Cross-cultural Leadership and Decision Making. 5. Apply the knowledge of behavioural skills learnt and integrate it with in interpersonal and intergroup environment emerging as future stable engineers and managers. 6. Apply the Labour Laws & Industrial Relations and various Act.	

Module No. & Name	Sub Topics	COs Mapped	Hours/ Sub Topic	Total Hours
i. Prerequisite and Course outline	Prerequisite Concepts and Course Introduction	-	02	02
1. Introduction Human Resource Management	1.1 Introduction to HR Human Resource Management-Concept, Scope and Importance, Interdisciplinary Approach Relationship with other Sciences, Competencies of HR Manager, HRM functions.	1	03	05
	1.2 Human resource development (HRD): changing role of HRM – Human resource Planning, Technological change, Restructuring and rightsizing, Empowerment, TQM, Managing ethical issues.	1	02	

Module No. & Name	Sub Topics	COs Mapped	Hours/ Sub Topic	Total Hours
2. Organizational Behaviour (OB)	2.1 Introduction to OB Origin, Nature and Scope of Organizational Behaviour, Relevance to Organizational Effectiveness and Contemporary issues.	2	02	07
	2.2 Personality: Meaning and Determinants of Personality, Personality development, Personality Types, Assessment of Personality Traits for Increasing Self Awareness.	2	01	
	2.3 Perception: Attitude and Value, Effect of perception on Individual Decision-making, Attitude and Behavior.	2	01	
	2.4 Motivation: Theories of Motivation and their Applications for Behavioural Change (Maslow, Herzberg, McGregor);	2	01	
	2.5 Group Behaviour and Group Dynamics: Work groups formal and informal groups and stages of group development. Team Effectiveness: High performing teams, Team Roles, cross functional and self-directed team, Case study.	2	02	
3. Organizational Structure & Design	3.1 Structure, size, technology, Environment of organization; Organizational Roles & conflicts: Concept of roles; role dynamics; role conflicts and stress.	3	02	06
	3.2 Leadership: Concepts and skills of leadership, Leadership and managerial roles, Leadership styles and contemporary issues in leadership.	3	02	
	3.3 Power and Politics: Sources and uses of power; Politics at workplace, Tactics and strategies.	3	02	
4. Human resource Planning	4.1 Recruitment and Selection process, Job-enrichment, Empowerment - Job-Satisfaction, employee morale.	4	01	05
	4.2 Performance Appraisal Systems: Traditional & modern methods, Performance Counselling, Career Planning.	4 & 6	02	
	4.3 Training & Development: Identification of Training Needs, Training Methods.	4	02	
5. Emerging Trends in HR	5.1 Organizational development; Business Process Re-engineering (BPR), BPR as a tool for organizational development, managing processes & transformation	4	03	06

Module No. & Name	Sub Topics	COs Mapped	Hours/ Sub Topic	Total Hours
	in HR. Organizational Change, Culture, Environment.			
	5.2 Cross Cultural Leadership and Decision Making**:** Cross Cultural Communication and diversity at work**,** Causes of diversity, managing diversity with special reference to handicapped, women and ageing people, intra company cultural difference in employee motivation.	5	03	
6. Strategic HRM	6.1 HR & MIS: Need, purpose, objective and role of information system in HR, Applications in HRD in various industries (e.g. manufacturing R&D, Public Transport, Hospitals, Hotels and service industries.	6	04	10
	6.2 Strategic HRM: Role of Strategic HRM in the modern business world, Concept of Strategy, Strategic Management Process, Approaches to Strategic Decision Making; Strategic Intent – Corporate Mission, Vision, Objectives and Goals	**6**	**03**	
	6.3 Labour Laws & Industrial Relations: Evolution of IR, IR issues in organizations, Overview of Labour Laws in India; Industrial Disputes Act, Trade Unions Act, Shops and Establishments Act.	6	03	
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization.	-	**01**	**01**
			Total Hrs.	**42**

Books:	
Text Books	1. S. Robbins, Organizational Behaviour, Pearson Education Limited. 2. V.S.P. Rao, Human Resource Management, Excel publishing. 3. K. Aswathapa, Human resource management: Text & cases.
Reference Books	1. C. B. Mamoria and S. V. Gankar, Dynamics of Industrial Relations in India, Himalaya Publishing. 2. P. Subba Rao, Essentials of Human Resource management and Industrial relations, Himalaya Publishing. 3. L. Mullins, Management & Organizational Behaviour, Pearson Publications.
Useful Links:	
1. https://www.nptel.ac.in/ 2. https://www.coursera.org/ 3. https://nptel.ac.in/courses/110/105/110105069/ 4. https://nptel.ac.in/courses/122/105/122105020/	

Continuous Assessment (40 Marks):
The distribution of Continuous Assessment marks will be as follows –

Class Test 1 (T-1)	20 marks
Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):
Two class tests of 20 marks each should be conducted in a semester. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing.

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Open Elective- Institute-level Course -II	Credits (TH+P+TUT)
ILC7055	**Professional Ethics and Corporate Social Responsibility (CSR)**	**3 + 0 + 0**
Course Objectives:	1. To understand professional ethics in business 2. To recognized corporate social responsibility	
Course Outcomes:	1. Explain rights and duties of business 2. Explain and understand the ethics in market and towards environment 3. Solve the problems of consumers and job discrimination ethically 4. Show corporate and social responsibility 5. Distinguish different aspects of corporate social responsibility 6. Explain global aspects of corporate social responsibility	

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hours
i. Prerequisite and Course outline	Prerequisite Concepts and Course Introduction	-	02	02
1. Professional Ethics and Business	The Nature of Business Ethics; Ethical Issues in Business; Moral Responsibility and Blame; Utilitarianism: Weighing Social Costs and Benefits; Rights and Duties of Business	1	04	04
2. Professional Ethics in the Marketplace	Perfect Competition; Monopoly Competition; Oligopolistic Competition; Oligopolies and Public Policy Professional Ethics and the Environment: Dimensions of Pollution and Resource Depletion; Ethics of Pollution Control; Ethics of Conserving Depletable Resources	3	08	08
3. Professional Ethics of Consumer Protection	Markets and Consumer Protection; Contract View of Business Firm‘s Duties to Consumers; Due Care Theory; Advertising Ethics; Consumer Privacy Professional Ethics of Job Discrimination: Nature of Job Discrimination; Extent of Discrimination; Reservation of Jobs.	3	06	06
4. Introduction to Corporate Social Responsibility:	Potential Business Benefits—Triple bottom line, Human resources, Risk management, Supplier relations; Criticisms and concerns—Nature of business; Motives; Misdirection. Trajectory of Corporate Social Responsibility in India	2	05	05
5. Corporate Social Responsibility	Articulation of Gandhian Trusteeship Corporate Social Responsibility and Small and Medium Enterprises (SMEs) in India, Corporate Social Responsibility and Public-Private Partnership (PPP) in India	2	08	08
6. Corporate Social Responsibility in Globalizing India	Corporate Social Responsibility Voluntary Guidelines, 2009 issued by the Ministry of Corporate Affairs, Government of India, Legal Aspects of Corporate Social Responsibility—Companies Act, 2013.	4	08	08
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization.	-	01	01
			Total Hrs.	**42**

Books:	
Text Books	1. Business Ethics: Texts and Cases from the Indian Perspective (2013) by Ananda Das Gupta; Publisher: Springer.
Reference Books	1. Corporate Social Responsibility: Readings and Cases in a Global Context (2007) by Andrew Crane, Dirk Matten, Laura Spence; Publisher: Routledge. 2. Business Ethics: Concepts and Cases, 7th Edition (2011) by Manuel G. Velasquez; Publisher: Pearson, New Delhi. 3. Corporate Social Responsibility in India (2015) by Bidyut Chakrabarty, Routledge, New Delhi.

Useful Links:

1. https://nptel.ac.in/courses/110/105/110105081/
2. https://nptel.ac.in/courses/110/105/110105079/

Continuous Assessment (40 Marks):
The distribution of Continuous Assessment marks will be as follows –

Class Test 1 (T-1)	20 marks
Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):
Two class tests of 20 marks each should be conducted in a semester. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing.

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Open Elective – Institute-level Course -II	Credits (TH+P+TUT)
ILC7056	**Research Methodology**	**3 + 0 + 0**
Prerequisites:	Basic level knowledge of research	
Course Objectives:	1. To understand Research and Research Process 2. To acquaint students with identifying problems for research and develop research strategies 3. To familiarize students with the techniques of data collection, analysis of data and interpretation.	
Course Outcomes:	1. Describe about the methodologies in research 2. Prepare a preliminary research design for projects in their subject matter areas. 3. Accurately collect, analyze and report data. 4. Present complex data or situations clearly. 5. Review and analyze research findings. 6. Summarize the different aspects and steps in conducting research.	

Module No. & Name	Sub Topics	COs Mapped	Hours/ Sub Topic	Total Hours
i. Prerequisite and Course outline	Prerequisite Concepts and Course Introduction	-	02	02
1. Introduction and Basic Research Concepts	1.1 Research – Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Research methods vs Methodology	1	2	09
	1.2 Need of Research in Business and Social Sciences		2	
	1.3 Objectives of Research		1	
	1.4 Issues and Problems in Research		2	
	1.5 Characteristics of Research: Systematic, Valid, Verifiable, Empirical and Critical		2	
2. Types of Research	2.1 Basic Research	2	1	07
	2.2 Applied Research		1	
	2.3 Descriptive Research		1	
	2.4 Analytical Research		1	
	2.5 Empirical Research		1	
	2.6 Qualitative and Quantitative Approaches		2	
3. Research Design and Sample Design	3.1 Research Design – Meaning, Types and Significance	1	4	07
	3.2 Sample Design – Meaning and Significance Essentials of a good sampling Stages in Sample Design Sampling methods/techniques Sampling Errors		3	
4. Research Methodology	4.1 Meaning of Research Methodology	2	1	08
	4.2 Stages in Scientific Research Process:		7	

Module No. & Name	Sub Topics	COs Mapped	Hours/ Sub Topic	Total Hours
	a. Identification and Selection of Research Problem b. Formulation of Research Problem c. Review of Literature d. Formulation of Hypothesis e. Formulation of research Design f. Sample Design g. Data Collection h. Data Analysis i. Hypothesis testing and Interpretation of Data j. Preparation of Research Report			
5. Formulating Research Problem	Considerations: Relevance, Interest, Data Availability, Choice of data, Analysis of data, Generalization and Interpretation of analysis	4	04	04
6. Outcome of Research	6.1 Preparation of the report on conclusion reached	3	02	04
	6.2 Validity Testing & Ethical Issues		01	
	6.3 Suggestions and Recommendation		01	
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization.	-	01	01
			Total Hrs.	**42**

Books:	
Text Books	1. C. Kothari, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited, 1985.
Reference Books	1. C. Dawson, Practical Research Methods, New Delhi, UBS Publishers Distributors, 2002. 2. R. Kumar, Research Methodology-A Step-by-Step Guide for Beginners, 2nd edition, Singapore, Pearson Education, 2005.

Useful Links:

https://libguides.newcastle.edu.au/researchmethods
https://nptel.ac.in/courses/121/106/121106007/

Continuous Assessment (40 Marks):
The distribution of Continuous Assessment marks will be as follows –

1.	Class Test 1 (T-1)	20 marks
2.	Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):
Two class tests of 20 marks each should be conducted in a semester. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing.

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Open Elective – Institute-level Course -II	Credits (TH+P+TUT)
ILC7057	IPR and Patenting	3 + 0 + 0
Course Objectives	1. To understand intellectual property rights protection system 2. To promote the knowledge of Intellectual Property Laws of India as well as International treaty procedures 3. To get acquaintance with Patent search and patent filing procedure and applications	
Course Outcomes	1. Explain Intellectual Property assets 2. Explain the enforcements in IPR 3. Investigate the issues in IPR. 4. Illustrate basics of patent. 5. Explain the patent rules 6. Apply the procedure of filing patent nationally and internationally	

Module No. & Name	Sub Topics	CO Mapped	Hour/ Sub Topic	Total Hours
i. Prerequisite and Course outline	Prerequisite Concepts and Course Introduction	-	02	02
1. Introduction to Intellectual Property Rights (IPR)	Meaning of IPR, Different categories of IPR instruments - Patents, Trademarks, Copyrights, Industrial Designs, Plant variety protection, Geographical indications, Transfer of technology etc. Importance of IPR in Modern Global Economic Environment: Theories of IPR, Philosophical aspects of IPR laws, Need for IPR, IPR as an instrument of development	1	05	05
2. Enforcement of Intellectual Property Rights	Introduction, Magnitude of problem, Factors that create and sustain counterfeiting/piracy, International agreements, International organizations (e.g. WIPO, WTO) active in IPR enforcement Indian Scenario of IPR: Introduction, History of IPR in India, Overview of IP laws in India, Indian IPR, Administrative Machinery, Major international treaties signed by India, Procedure for submitting patent and Enforcement of IPR at national level etc.	2	07	07
3. Emerging Issues in IPR	Challenges for IP in digital economy, e- commerce, human genome, biodiversity and traditional knowledge etc.	2	05	05
4. Basics of Patents	Definition of Patents, Conditions of patentability, Patentable and non-patentable inventions, Types of patent applications (e.g. Patent of addition etc), Process Patent and Product Patent, Precautions while patenting, Patent specification Patent claims, Disclosures and non-disclosures, Patent rights and infringement, Method of getting a patent	3	07	07
5. Patent Rules	Indian patent act, European scenario, US scenario, Australia scenario, Japan scenario, Chinese scenario, Multilateral treaties where India is a member (TRIPS agreement, Paris convention etc.)	3	08	08

Module No. & Name	Sub Topics	CO Mapped	Hour/ Sub Topic	Total Hours
6. Procedure for Filing a Patent (National and International)	Legislation and Salient Features, Patent Search, Drafting and Filing Patent Applications, Processing of patent, Patent Litigation, Patent Publication, Time frame and cost, Patent Licensing, Patent Infringement Patent databases: Important websites, Searching international databases	3	07	07
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization.	-	01	01
			Total Hrs.	**42**

Books:	
Text Books	1. Rajkumar S. Adukia, 2007, A Handbook on Laws Relating to Intellectual Property Rights in India, The Institute of Chartered Accountants of India 2. Keayla B K, Patent system and related issues at a glance, Published by National Working Group on Patent Laws 3. T Sengupta, 2011, Intellectual Property Law in India, Kluwer Law International 4. Tzen Wong and Graham Dutfield, 2010, Intellectual Property and Human Development: Current Trends and Future Scenario, Cambridge University Press 5. Cornish, William Rodolph & Llewelyn, David 2010, Intellectual Property: Patents, Copyrights, TradeMarks and Allied Right, 7th Edition, Sweet & Maxwell
Reference Books	1. Lous Harns, 2012, The enforcement of Intellectual Property Rights: A Case Book, 3rd Edition, WIPO 2. Prabhuddha Ganguli, 2012, Intellectual Property Rights, 1st Edition, TMH 3. R Radha Krishnan & S Balasubramanian, 2012, Intellectual Property Rights, 1st Edition, Excel Books 4. M Ashok Kumar and mohd Iqbal Ali, 2-11, Intellectual Property Rights, 2nd Edition, Serial Publications 5. Kompal Bansal and Praishit Bansal, 2012, Fundamentals of IPR for Engineers, 1st Edition, BS Publications 6. Entrepreneurship Development and IPR Unit, BITS Pilani, 2007, A Manual on Intellectual Property Rights, 7. Mathew Y Maa, 2009, Fundamentals of Patenting and Licensing for Scientists and Engineers, World Scientific Publishing Company 8. N S Rathore, S M Mathur, Priti Mathur, Anshul Rathi, IPR: Drafting,Interpretation of Patent Specifications and Claims, New India Publishing Agency 9. Vivien Irish, 2005, Intellectual Property Rights for Engineers,IET 10. Howard B Rockman, 2004, Intellectual Property Law for Engineers and scientists, Wiley-IEEE Press

Useful Links:

1. https://nptel.ac.in/courses/110/105/110105139/
2. https://nptel.ac.in/courses/109/105/109105112/

Continuous Assessment (40 Marks):

The distribution of Continuous Assessment marks will be as follows –

Class Test 1 (T-1)	20 marks
Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):

Two class tests of 20 marks each should be conducted in a semester. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing.

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Open Elective - Institute-level Course– II	Credits (TH+P+TUT)
ILC7058	**Digital Business Management**	**3 + 0+ 0**
Prerequisite	Business Intelligence	
Course Objectives	1. To familiarize with digital business concept 2. To acquaint with E-commerce 3. To give insights in to E-business and its strategies	
Course Outcomes	1. Identify drivers of digital business 2. Reviewing the concepts of E-commerce 3. Devise the services of Digital Business 4. Illustrate various techniques of managing E-business 5. Illustrate various approaches of E-business Strategy 6. Prepare E-business Plan	

Module No. & Name	Sub Topics	CO Mapped	Hrs./ Sub Topic	Total Hrs/ Module
i. Prerequisite and Course outline	Prerequisite Concepts and Course Introduction	-	02	02
1. Introduction to Digital Business	Introduction to Digital Business Introduction, Background and current status, E-market places, structures, mechanisms, economics and impacts Difference between physical economy and digital economy. Drivers of digital business- Big Data & Analytics, Mobile, Cloud Computing, Social media, BYOD, and Internet of Things (digitally intelligent machines/services) Opportunities and Challenges in Digital Business.	1	09	09
2. Overview of E-Commerce	Meaning, Retailing in e-commerce-products and services, consumer behaviour, market research and advertisement B2B-E-commerce-selling and buying in private e-markets, public B2B exchanges and support services, e-supply chains, Collaborative Commerce, Intra business EC and Corporate portals Other E-C models and applications, innovative EC System-From E-government and learning to C2C, mobile commerce and pervasive computing EC Strategy and Implementation-EC strategy and global EC, Economics and Justification of EC, Using Affiliate marketing to promote your e-commerce business, Launching a successful	2	06	06

Module No. & Name	Sub Topics	CO Mapped	Hrs./ Sub Topic	Total Hrs/ Module
	online business and EC project, Legal, Ethics and Societal impacts of EC.			
3. Digital Business Support services	ERP as e –business backbone, knowledge Tope Apps, Information and referral system Application Development: Building Digital business Applications and Infrastructure.	3	06	06
4. Managing E-Business	Managing Knowledge, Management skills for e-business, Managing Risks in e –business Security Threats to e-business -Security Overview, Electronic Commerce Threats, Encryption, Cryptography, Public Key and Private Key Cryptography, Digital Signatures, Digital Certificates, Security Protocols over Public Networks: HTTP, SSL, Firewall as Security Control, Public Key Infrastructure (PKI) for Security, Prominent Cryptographic Applications.	4	06	06
5. E-Business Strategy	E-business Strategic formulation- Analysis of Company‘s Internal and external environment, Selection of strategy, E-business strategy into Action, challenges and E-Transition (Process of Digital Transformation).	5	04	04
6. Materializing e-business	From Idea to Realization-Business plan preparation Case Studies and presentations	6	08	08
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization.	-	01	01
			Total Hrs.	**42**

Books:	
Text Books	1. A textbook on E-commerce, Er. Arunrajan Mishra, Dr. W K Sarwade, Neha Publishers & Distributors, 2011 2. Digital Business and E-Commerce Management, 6th Ed, Dave Chaffey, Pearson, August 2014 3. Digital Business Concepts and Strategy, Eloise Coupey, 2nd Edition, Pearson 4. Perspectives the Digital Enterprise –A framework for Transformation, TCS consulting journal Vol.5 5. Measuring Digital Economy-A new perspective DoI:10.1787/9789264221796-enOECD Publishing

Reference Books	1. E-commerce from vision to fulfilment, Elias M. Awad, PHI-Restricted, 2002 2. Introduction to E-business-Management and Strategy, Colin Combe, ELSEVIER, 2006 3. Trend and Challenges in Digital Business Innovation, Vincenzo Morabito, Springer. 4. Digital Business Discourse Erika Darics, April 2015, Palgrave Macmillan. 5. 5. E-Governance-Challenges and Opportunities in : Proceedings in 2nd International Conference theory and practice of Electronic Governance

Useful Links:

1. https://nptel.ac.in/courses/110/105/110105083/
2. https://onlinecourses.nptel.ac.in/noc19_mg54/preview

Continuous Assessment (40 Marks):
The distribution of Continuous Assessment marks will be as follows –

Class Test 1 (T-1)	20 marks
Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):
Two class tests of 20 marks each should be conducted in a semester. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing.

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Course Code	Open Elective - Institute-level Course– II	Credits (TH+P+TUT)
ILC7059	**Environmental Management**	**3 + 0 + 0**
Prerequisites	General Awareness of environment and factors affecting the environment.	
Course Objectives	1. To understand and identify environmental issues relevant to India and global concerns **2.** To learn concepts of ecology **3.** To familiarise environment related legislations 4. To understand to protect and sustain our natural resources of land, water, air, and vegetation.	
Course Outcomes	1. Interpret the concept of environmental management 2. Learn the ecosystem and interdependence, food chain etc. and interpret environment related legislations 3. Identify the environmental issues important to India 4. Learn the regulating policies of Government in environmental management 5. Identify solutions to protect the environment from pollution 6. Examine the quality environmental management	

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs
i. Prerequisite and Course outline	Prerequisite Concepts and Course Introduction	-	02	02
1. Introduction and Definition of Environment	1.1 Significance of Environment Management for contemporary managers	1	02	10
	1.2 Career opportunities		01	
	1.3 Environmental issues relevant to India		02	
	1.4 Sustainable Development		03	
	1.5 The Energy scenario		02	
2. Global Environmental concerns	2.1 Global Warming	4	01	06
	2.2 Acid Rain		01	
	2.3 Ozone Depletion		01	
	2.4 Hazardous Wastes		30 min	
	2.5 Loss of Biodiversity		30 min	
	2.6 Industrial/Man-made		01	
	2.7 Industrial/Man-made disasters / Atomic / Biomedical hazards, etc		01	
3. Concepts of Ecology	3.1 Ecosystems and interdependence between living organisms	2	01	05
	3.2 Habitats		30 min	
	3.3 Limiting factors		30 min	
	3.4 Carrying capacity		01	
	3.5 Food chain		01	
	3.6 Ecology		01	
	4.1 Scope of Environment Management	5	03	10

Module No. & Name	Sub Topics	CO Mapped	Hrs/ Sub Topic	Total Hrs
4. Scope of Environment Management	4.2 Role and functions of Government as a planning and regulating agency		03	
	4.3 Environment Quality Management and Corporate Environmental		04	
5. Quality Environmental Management	5.1 Total Quality Environmental Management	1	02	05
	5.2 ISO-14000		02	
	5.3 EMS certification		01	
6. General overview of major legislations	Environment Protection Act, Air (P & CP) Act, Water (P & CP) Act, Wildlife Protection Act, Forest Act, Factories Act	3	03	03
ii. Course Conclusion	Recap of Modules, Outcomes, Applications and Summarization.	0	01	01
			Total Hrs.	**42**

Books:	
Text Books	1. Environmental Management: Principles and Practice, C J Barrow, Routledge Publishers London, 1999 2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell, Edward Elgar Publishing 3. Environmental Management V Ramachandra and Vijay Kulkarni, TERI Press
Reference Books	1. Indian Standard Environmental Management Systems — Requirements With Guidance For Use, Bureau Of Indian Standards, February 2005 2. Introduction to Environmental Management, Mary K Theodore and Louise Theodore, CRC 3. Environment and Ecology, Majid Hussain, 3rd Ed. Access Publishing.2015 4. Environmental Management: An Indian Perspective, S N Chary and Vinod Vyasulu, Macmillan India, 2000

Useful Links:

1. https://libguides.library.qut.edu.au/EVB302_Environmental_pollution/links
2. https://www.epd.gov.hk/epd/epic/english/epichome.html
3. http://www.ecovacservices.com/Useful-Links-6-5511.html

Continuous Assessment (40 Marks):

The distribution of Continuous Assessment marks will be as follows –

Class Test 1 (T-1)	20 marks
Class Test 2 (T-2)	20 marks

Class Tests (20 Marks):

Two class tests of 20 marks each should be conducted in a semester. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus (but excluding contents covered in Test I) is completed. Duration of each test shall be one hour. Addition of both test scores will be considered for passing.

End Semester Theory Examination will be of 60 Marks with Two Hours and 30 Minutes duration.

Lan Code	Lab Name	Credits (P+TUT)
EXL701	**Microwave Engineering Laboratory**	**(1+0)**
Prerequisite	1. Electromagnetic and Antenna Laboratory 2. Principles of Communication Engineering Laboratory	
Lab. Objectives	1. To learn the design of matching circuit using simulation software. 2. To learn the mode analysis in waveguide using simulation software. 3. To learn microwave passive components and semiconductor devices. 4. To analyse the characteristics of microwave tubes (Reflex Klystron). 5. To measure microwave parameters using microwave bench.	
Lab. Outcomes (LO)	1. Analyse microwave matching techniques and waveguide using any simulation software. 2. Analyse microwave passive components and semiconductor devices. 3. To measure microwave parameters using microwave bench. 4. Write a code for the calculation of Speed, cross range & Range of Doppler Radar. 5. Write accurate documentation for experiments performed. 6. Apply ethical principles like timeliness and adhere to the rules of the laboratory.	

Lab. No.	Experiment Title (suggested)	LO Mapped	Hrs. / Lab
0	Lab Prerequisites	-	02
1.	Measurement of Microwave Frequency Using Slotted Line section and verification using direct frequency meter.	3	02
2.	Study and analyse the characteristics of Reflex Klystron.	2	02
3.	Demonstrate the measurement of Voltage Standing Wave Ratio & Reflection Coefficient of Different load.	3	02
4.	Demonstrate the measurement of Guided Wavelength & Free Space Wavelength using Microwave bench.	3	02
5.	Study and modal analysis of Rectangular waveguide using simulation software.	1	02
6.	Demonstrate the measurement of dielectric constant of solid using Microwave bench.	3	02
7.	Simulation of impedance matching by using any familiar software.	1	02
8.	Write a code for the calculation of Speed, cross range & Range of Doppler Radar by using any familiar software.	4	02
9.	To analyses the performance of Gunn diode using Microwave bench.	2	02
10.	Analysis of E, H and Magic Tees using any simulation software.	1	02
11.	Analysis of Circulator using any simulation software	1	02
12.	Mini Project/ Case study	-	-
13.	Assignment 1	-	-
14.	Assignment 2	-	-
	Total Hrs.		**24**

Virtual as well as You tube Lab Links:
1. http://www.iitk.ac.in/mimt_lab/vlab/index.php 2. https://onlinecourses.nptel.ac.in/noc19_ee57/preview 3. https://www.youtube.com/c/KJSIEITofficial/videos
Term work: (25 Marks)
1. Term work should consist of a minimum of 8 experiments 2. Journal must include assignments on content of theory and practical of the course 3. The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work. 4. Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments/Case study/demo/presentation: 05-marks)
Oral/Practical/P&O : P&O (25 Marks)
P&O examination will be based on experiment list and performance of experiment

Lab Code	Lab Name	Credits (P+TUT)
EXDLL8022	**Mobile Communication Systems Laboratory**	**1+0**
Lab Prerequisite	Python Programming Analog and Digital Communication Engineering Lab.	
Lab Objectives	1. To implement and analyze cellular communication techniques. 2. To simulate mobile communication network models and propagation effects. 3. To implement advanced wireless techniques such as beamforming and smart antennas. 4. To analyze spectrum, signals, and emerging technologies in mobile communication systems..	
Lab Outcomes (LO)	1. Implement and analyze cellular communication fundamentals and capacity techniques. 2. Analyze propagation models and fading characteristics in wireless communication systems. 3. Simulate GSM, CDMA, and 3G mobile communication technologies. 4. Demonstrate LTE and advanced wireless communication techniques. 5. Analyze Massive MIMO, cognitive radio, and 5G communication concepts. 6. Prepare proper documentation and follow ethical laboratory practices.	

Lab No.	Experiment Title	LO Mapped	Hrs/ Lab
0	Lab Prerequisites	-	02
1	Simulate and perform Co-Channel Interference Analysis of Frequency Reuse in Cluster-Based Cellular Networks.	1,6	02
2	Implement Channel Assignment strategies and perform Cellular Capacity Analysis	1,6	02
3	Simulate Free Space Propagation Model.	4,6	02
4	Implement Knife edge diffraction model.	4,6	02
5	Analyze the Two-Ray Ground Reflection Propagation Model	2,6	02
6	Simulation and Performance Analysis of Rayleigh and Rician Fading Channels.	2,6	02
7	Perform Link Budget Analysis for Mobile Communication Systems	2,6	02
8	Simulation and Performance Analysis of Power Control Mechanisms in CDMA Systems	3,6	02
9	Perform LTE Physical Channel and Scheduling Simulation	4,6	02
10	Implement Smart Antenna Beamforming for 4G networks.	5,6	02
11	Simulation and Performance Evaluation of Cognitive Radio Spectrum Sensing Techniques	5,6	02
12	Create a simulation environment for Device-to-Device (D2D) Communication.	5,6	02
		Total Hrs.	**24**

Virtual Lab Links:

1. http://simu5g.org/
2. https://ourtechplanet.com/5g-rf-design-planning-fundamentals/
3. https://wc-iiith.vlabs.ac.in/
4. https://www.mathworks.com/products/matlab-online.html

Term work: (25 Marks)

1. Term work should consist of a minimum of 8 experiments
2. Journal must include assignments on content of theory and practical of the course
3. The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work.
4. Total 25 Marks (Experiments: 15-marks, Assignments/Case study/demo/presentation: 10-Marks)

Oral/Practical/P&O: (25 Marks)

P&O examination will be based on the entire theory syllabus and carries 25 Marks.

Lab Code	Lab Name	Credits (P+TUT)
EXDLL7041	**Major / Professional Elective - Department-level Course – IV** **Neural Networks and Deep Learning Laboratory**	(1+0)

Lab Prerequisite:	Machine Learning
Lab Objectives:	1. To simulate the various phenomenon related to CMOS circuits 2. To analyze simple CMOS circuits using SPICE tools 3. To simulate the logic circuits using various design style 4. To draw mask layout of various circuits
Lab Outcomes (LOs):	After taking the course students will be able to, 1. Demonstrate implementation of perceptron. 2. Build Neural Network model for the given problem 3. Implement a Neural Network for the given problem using various libraries. 4. Tune the parameters of Neural Networks. 5. Write accurate documentation for experiments performed. 6. Apply ethical principles like timeliness and adhere to the rules of the laboratory

Lab No	Experiment Title	LO Mapped	Hrs/ Lab
0	Lab Prerequisites	-	02
1.	Implementation of perceptron	1,5,6	02
2.	Implementation of shallow dense neural network with one hidden layer	2,5,6	02
3.	Implementation of Stochastic Gradient Descent	2,5,6	02
4.	Implementation of dropout	4,5,6	02
5.	Implementation of regularization	4,5,6	02
6.	Implementation of RMSprop optimizer	4,5,6	02
7.	Implementation of Adam optimizer	4,5,6	02
8.	Build and implement A Deep Learning Model using Keras	3,5,6	02
9.	Hyper parameter tuning for Neural Network	4,5,6	02
10.	Implementation of ConvNet for using PyTorch	3,5,6	02
11.	Implementation of LeNet-5 using PyTorch	3,5,6	02
12.	Implementation of AlexNet using Keras	3,5,6	02
13.	Implementation of ResNet using Keras	3,5,6	02
		Total Hrs.	**24**

Virtual Lab Links:
http://cse22-iiith.vlabs.ac.in/
Term work: (25 Marks)
1. Term work should consist of a minimum of 8 experiments 2. Journal must include assignments on content of theory and practical of the course 3. The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing marks in term work. **4.** Total 25 Marks (Experiments: 15-marks, Assignments/Case study/demo/presentation: 10-marks)
Oral/Practical/P&O: (25 Marks)
P&O examination will be based on entire theory syllabus and carries 25 Marks

Lab Code	Lab Name	Credits (P+TUT)
EXDLL7042	**Major / Professional Elective - Department-level Course – IV Wireless Networks Laboratory**	**1+0**
Lab Prerequisite	Computer Communication Networks Laboratory	
Lab Objectives	1. Study of Hardware and Software aspects of Wireless Network and IoT 2. Analysis of ZigBee network wireless transmission of information. 3. Configuration of WPAN using Bluetooth module. 4. Link budget analysis of GSM and CDMA network	
Lab Outcomes (LOs)	1. Implement capacity and network efficiency of different multiple access schemes like, SCMA, OFDMA, 2. Design WPAN, WLAN, WMAN and WWAN. 3. Estimate link budget of GSM, CDMA, HSDPA, CDMA2000 4. Implement Wireless Ad hoc Networks, Sensor Network and IoT. 5. Write accurate documentation for experiments performed. 6. Apply ethical principles like timeliness and adhere to the rules of the laboratory.	

Lab No.	Experiment Title	LO Mapped	Hrs./ Lab
0	Lab Prerequisites	-	02
1	Study of Hardware and Software Tools for Wireless Networks and Internet of Things (IoT)	1	02
2	Establish and Configure a Bluetooth Network Connection	2	02
3	Estimation of Interference Range in Bluetooth and IEEE 802.11a Networks	2	02
4	Estimation of Capacity and Spectral Efficiency in CDMA Systems	1	02
5	Calculation of Uplink and Downlink Link Budgets for CDMA Systems	3	02
6	Simulation of SINR Performance in High-Speed Downlink Packet Access (HSDPA)	3	02
7	To turn motor, relay on and off using ZigBee kit	2	02
8	Establish Wireless Local Area Network.	2	02
9	Simulation of AI-Based Sensor Node Deployment and Intelligent Connectivity in Wireless Sensor Networks	4	02
10	To understand basic beamforming in wireless communication using artificial intelligence	1	02
11	Implementation of a Wireless Metropolitan Area Network (WMAN)	4	02
12	Mini projects based on wireless technologies simulation/ coding using MATLAB/NS3/Scilab	1-6	-
		Total Hrs.	**24**
Note: Lab Outcomes 05 and 06 are mapped to all experiments and Mini project			

Useful Links:
http://vlabs.iitkgp.ernet.in/ant/
Term work: (25 Marks)
1. Term work should consist of a minimum of 8 experiments **2.** Journal must include assignments on content of theory and practical of the course **3.** The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work. 4. Total 25 Marks (Experiments, Attendance Theory & Practical: 15-marks, Assignments/Case study/Mini project demo/presentation: 10-marks
Oral/Practical/P&O: (25 Marks)
P&O examination will be based on experiment list and performance of experiment carries 25 Marks

Lab Code	Lab Name	Credits (P+TUT)
EXDLL7043	**Major / Professional Elective - Department-level Course – IV** **Autonomous Vehicle Laboratory**	1+0

Lab Prerequisite	1. Microcontroller 2. Image processing
Software Requirements	• STM32CubeIDE • Python 3.x • OpenCV (basic) • BUSMASTER/SocketCAN • Keil uVision (optional)
Lab Objectives	1. Interface automotive sensors using embedded systems. 2. Acquire and process sensor data. 3. Implement automotive communication protocols. 4. Develop embedded navigation and control algorithms. 5. Evaluate autonomous vehicle subsystems
Lab Outcomes (Los)	1. Interface automotive sensors using embedded hardware. 2. Acquire and process sensor data for perception. 3. Implement embedded communication using CAN. 4. Develop embedded navigation and control modules. 5. Analyze safety and reliability of embedded autonomous vehicle subsystems. 6. Apply ethical principles like timeliness and adhere to the rules of the laboratory

Lab No.	Experiment Title	LO Mapped	Hrs./ Lab
0	Study of autonomous vehicle embedded architecture and ECU hierarchy	1	02
1	Interface ultrasonic sensor for obstacle distance measurement using STM32	1	02
2	Interface IMU (MPU6050) and estimate orientation	2	02
3	GPS interfacing and location acquisition	2	02
4	Wheel encoder interfacing and odometry estimation	2	02
5	Motor speed control using PWM and PID	4	02
6	Servo steering angle control	4	02
7	CAN communication between two STM32 boards	3	02
8	Adaptive Cruise Control logic using ultrasonic sensor	4	02
9	Conceptual sensor fusion using Ultrasonic + IMU + Encoder	2	02
10	Lane detection using OpenCV	2	04
11	Object detection using OpenCV	2	02
12	Mini Project: Embedded Autonomous Vehicle Prototype	1-6	02
	Total Hrs.		**24**

Useful Links:

1. https://www.st.com/en/development-tools/stm32cubeide.html
2. https://www.st.com/en/embedded-software/x-cube-mcsdk.html
3. https://docs.simplefoc.com/
4. https://controllerstech.com/stm32-hal/peripherals/timer-tutorials/
5. Arduino Field Oriented Control (FOC) Open Source Library Demonstration – Simple FOC project- https://www.youtube.com/watch?v=Y5kLeqTc6Zk&t=259s
6. https://controllerstech.com/can-protocol-in-stm32/
7. https://www.mathworks.com/help/driving/ug/adaptive-cruise-control-with-sensor-fusion.html
8. 10 Min Tutorial Of OpenCV Python: Find Lanes For Self Driving Cars – Lane Detection - https://youtu.be/sg-Kn5n6q60
9. AUTOSAR_EXP_LayeredSoftwareArchitecture.pdf
10. https://www.autosar.org/standards/classic-platform/

Term work: (25 Marks)

1. Term work should consist of a minimum of 8 experiments
2. Journal must include assignments on content of theory and practical of the course
3. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4. Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments/Case study/demo/presentation: 05-marks)

Oral/Practical/P&O: (25 Marks)

P&O examination will be based on experiment list and performance of experiment.

Lab Code	Lab Name	Credits (P+TUT)
EXDLL7044	**Major / Professional Elective - Department-level Course – IV** **Cloud Computing & Security Lab**	1+0
Lab Prerequisite:	1. Computer Communication Networks 2. Data Structure & Algorithms	
Lab Objectives:	Students to get familiar with: 1. Understand the concepts and implementation of virtualization and virtual machine management. 2. Explore and implement cloud service models and cloud computing platforms. 3. Configure and manage cloud infrastructure services including storage, security, and monitoring. 4. Develop skills in containerization and orchestration using Docker and Kubernetes.	
Lab Outcomes (LOs):	Students should be able to: 1. Create, configure, and manage virtual machines using different hypervisors. 2. Implement cloud service models (IaaS, PaaS, and SaaS) using cloud platforms and open-source cloud technologies. 3. Configure and manage cloud storage, security, monitoring, and identity services for reliable cloud environments. 4. Deploy, manage, and orchestrate containerized applications using Docker and Kubernetes. 5. Maintain proper documentation of experiments and technical procedures. 6. Apply professional ethics, punctuality, and adhere to laboratory rules and practices.	

Lab No.	Experiment Title	LO Mapped	Hrs/ Lab
0	Lab Prerequisites	-	02
1.	To study and implement Bare Metal Hypervisor using KVM (Ubuntu/Linux with KVM & libvirt)	1,5,6	02
2.	Building and Running Virtual Machines with Hosted KVM Hypervisors	1,5,6	02
3.	To study and implement Bare Metal Hypervisor using Xen Project Hypervisor (Ubuntu/Debian Linux)	1,5,6	02
4.	Configure your instance firewall (Oracle Cloud / Local Linux VM using UFW or firewalld/AWS/GC)	3,5,6	02
5.	Replace or Attach an IAM Role to an Existing EC2 Instance by using the EC2 Console	3,5,6	02
6.	Demonstration and Implementation of IaaS Using OpenStack / Apache CloudStack / Proxmox VE/ AWS/ Google Cloud	2,5,6	02

Lab No.	Experiment Title	LO Mapped	Hrs/ Lab
7.	Create your first Cloud Storage bucket using Amazon Simple Storage Service (Amazon S3)	2,3,5,6	02
8.	Monitors your resources and the applications you run on Cloud Platform in real time using Amazon CloudWatch	2,3,5,6	02
9.	To demonstrate deployment of Web Application using Platform as a Service (PaaS) (using Elastic Beanstalk / Microsoft Azure /App Service/ Dokku / CapRover / Coolify)	3,5,6	02
10.	To implement Load Balancing and Auto Scaling using Elastic Load Balancer (ELB)	3,5,6	02
11.	Case study / Project	1-6	--
		Total Hrs.	**24**

Note: A minimum of 8 laboratory exercises must be completed from the above list covering virtualization, cloud computing services, cloud programming, and cloud security, using tools such as AWS, GCP, Azure, Docker, Kubernetes, or similar platforms, or any other relevant exercises aligned with the Cloud Computing and Security syllabus and current cloud industry practices.

References:

1. M. Scott Kingsley, Cloud Technologies and Services: Theoretical Concepts and Practical Applications, Springer, 2024.
2. Boyce Gowans, Mastering Cloud Computing with AWS, Azure, and GCP, 2025.
3. Azhar ul Haque Sario, Cloud Computing: AWS, Azure, and Google Cloud, 2025.
4. Divit Gupta, The Cloud Computing Journey, Packt Publishing, 2024.
5. Thomas Erl, Zaigham Mahmood, Ricardo Puttini, Cloud Computing: Concepts, Technology & Architecture, Pearson, 2013.

Useful Links:

1. www.openstack.org
2. ttps://www.nist.gov/news-events/news/2011/10/final-version-nist-cloud-computing-definition-published
3. https://cloudsecurityalliance.or

Termwork (25 Marks)

1. Term work should consist of a minimum of 8 experiments.
2. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

Oral/Practical/P&O: (25 Marks)

P&O examination will be based on experiment list and performance of experiment.

Lab Code	Lab Name	Credits (P+TUT)
EXDLL7045	**Major / Professional Elective - Department-level Course – IV** **System on Chip Laboratory**	**1+0**
Lab Prerequisite	1. Digital VLSI Design and Verilog HDL 2. Microprocessors and Microcontrollers 3. Basic Python/C programming and Project Based Learning II	
Lab Objectives	1. To introduce practical hardware-software co-design using the PYNQ-Z2 System-on-Chip platform. 2. To develop AXI-based peripherals and hardware accelerators using RTL and High-Level Synthesis. 3. To implement, verify, debug, and evaluate an integrated SoC application using PS, PL, memory, and DMA. 4. To expose learners to implementation reports, low-power methods, security, reliability, and emerging SoC extensions.	
Lab Outcomes	1. Interpret the PYNQ-Z2 architecture and partition an application between the Processing System and Programmable Logic. 2. Develop PS software to configure peripherals and hardware accelerators using MMIO, interrupts, and device interfaces. 3. Integrate AXI4-Lite, AXI4-Stream, BRAM/DDR, DMA, and custom IP to realize a complete SoC application. 4. Design, verify, optimize, and evaluate RTL/HLS accelerator IP using simulation, co-simulation, implementation reports, and on-chip debugging. 5. Write accurate documentation for experiments performed. 6. Apply ethical principles like timeliness and adhere to the rules of the laboratory.	

Lab No	Experiment Title	LO Mapped	Hrs/ Lab
0	Lab prerequisites: PYNQ-Z2 board setup, Vivado/PYNQ workflow, review of Verilog, Python, image representation, and laboratory sfety.	-	02
1	Design a PS only system. Study the PYNQ-Z2 architecture and develop the system block diagram and hardware-software partition for the smart-camera edge-processing SoC. Implement a PS-only Python/OpenCV Sobel application, generate the golden-reference output, and record software execution time.	1,2,5,6	02
2	Create a basic PS-PL system using AXI GPIO. Control LEDs and read push-buttons from the PS through MMIO; study the memory map, processor peripherals, device control, and the role of the software stack.	2,3,5,6	02
3	Design AXI4-Lite communication system Design, verify, package, and integrate a custom AXI4-Lite RTL control/status peripheral for the running example. Implement configuration, start, status, threshold, image-size, and error registers, and access them using PS software.	2,3,4,5,6	02
4	Develop the data-movement subsystem using BRAM/DDR,	2,3,4,5,6	04

Lab No	Experiment Title	LO Mapped	Hrs/ Lab
	an AXI4-Stream loopback datapath, and AXI DMA. Transfer image data between PS memory and PL; study address mapping, TLAST, transfer correctness, cache/data-consistency issues, and BRAM-versus-DDR trade-offs.		
5	Design an RTL pixel pre-processing IP for thresholding or grayscale normalization. Develop a testbench, verify normal and boundary cases, synthesize the IP, and interpret timing and resource-utilization reports.	1,3,4,5,6	02
6	Develop the Sobel edge-detection accelerator using C/C++ High-Level Synthesis. Perform C simulation, interface synthesis, and C/RTL co-simulation, and optimize the design using pipelining, dataflow, loop unrolling, and resource sharing. Compare latency, initiation interval, throughput, and resource utilization.	1,3,4,5,6	04
7	Integrate the HLS Sobel accelerator with AXI4-Lite control, AXI4-Stream, DMA, DDR, and the ARM Processing System. Create a PYNQ overlay, implement interrupt-driven accelerator/DMA completion, and execute the complete hardware-software co-designed pipeline.	1,2,3,4,5, 6	04
8	Verify, validate, and debug the integrated SoC using directed images , software scoreboarding, golden-reference comparison, protocol checks, and the Integrated Logic Analyzer. Observe AXI handshaking, stalls, TLAST, and DMA behavior, and diagnose a deliberately introduced fault.	3,4,5,6	02
9	Analyze synthesis, placement, routing, timing, clocking, resource utilization, and power reports for the complete SoC. Study PPA trade-offs using clock-enable or frequency changes, and add reliability/security checks such as bounds validation, malformed-stream detection, timeout/watchdog, error reporting, and secure-boot/bitstream-protection awareness.	1,3,4,5,6	02
10	Demonstrate the final smart-camera edge-processing SoC and compare PS-only and hardware-accelerated implementations for correctness, latency, throughput, and resource/power cost. Document the complete design and present an extension toward an AI accelerator, heterogeneous SoC, or chiplet-based implementation.	1,2,3,4,5, 6	02
		Total Hrs.	**28***

Useful Links:

1. https://blog.umer-farooq.com/a-pynq-z2-guide-for-absolute-dummies-part-i-fun-with-leds-and-switches-47dd76abf9a9
2. https://blog.umer-farooq.com/a-pynq-z2-guide-for-absolute-dummies-part-ii-using-verilog-and-vivado-to-burn-code-on-pynq-d856f79948b1
3. https://community.element14.com/members-area/personalblogs/b/blog/posts/pynq-z2-workshop---ps-gpio
4. https://www.youtube.com/watch?v=zbumITJQ2Z8
5. https://www.youtube.com/watch?v=_odNhKOZjEo
6. https://discuss.pynq.io/t/tutorial-pynq-dma-part-1-hardware-design/3133
7. https://community.element14.com/products/roadtest/b/blog/posts/pynq-z2-dev-kit---working-with-base-overlays
8. https://support.xilinx.com/s/article/63041?language=en_US

Term work: (25 Marks)

1. Term work should consist of all 10 experiments and the integrated running-example demonstration or mini-project.
2. The journal shall include circuit/block diagrams, source code, software notebooks, simulation/co-simulation results, implementation reports, observations, performance comparison, and conclusions.
3. The journal shall include assignments/case studies linking the laboratory work with ARM versus RISC-V, AXI versus NoC, cache coherency, physical implementation, low-power design, hardware security, AI accelerators, and chiplet-based SoCs.
4. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
5. Total 25 Marks: Experiments and journal - 15 marks; assignments/ case study/ demo/ presentation/ mini-project - 10 marks.

Oral/Practical/P&O: (25 Marks)

P&O examination will be based on the entire theory syllabus, laboratory work, and the integrated running example and carries 25 Marks.

Lab Code	Community Engagement PBL - Innovation-Based Major Project	Credits (P+TUT)
EXPR75	**Major Project – B**	**(6+0)**

Lab Prerequisite	Major Project – A
Lab Objectives	1. To meet the milestones formed in the overall project plan decided in Major Project-A. 2. To implement idea presented in Major Project -A with results, conclusion and future work. 3. To culminate the production of a thesis by each individual student. 4. To apply professional ethics, teamwork, and modern engineering tools in project execution.
Lab Outcomes (LOs)	1. Identify, formulate, review research literature, and analyze complex engineering problems. 2. Design solutions, components, or processes for complex engineering problems. 3. Select appropriate modern engineering tools and analyze and interpret data to meet the problem statement. 4. Apply ethical principles and commit to professional ethics, responsibilities norms of the engineering practice, and engage in independent and life-long learning. 5. Comprehend and write effective reports and design documentation, deliver effective presentations and communicate clear instructions effectively. 6. Interact efficiently and effectively as an individual with the team members or leader for timely and professional management of projects.

Guidelines:

Project Report Format:

At the end of the semester the student needs to prepare a project report which should be prepared. Along with the project Black book, project documentation, Implementation code, required utilities, soft wares and user Manuals need to be submitted in the soft copy.

Useful Links:

1. https://ieeexplore.ieee.org/
2. https://www.electronicsforu.com/

Term Work: (50 Marks)

Students have to submit a weekly progress report to the internal guide and the internal guide has to keep a track on the progress of the project and also has to maintain the attendance report. This progress report can be used for awarding the term work marks. In case of industry projects, visits by an internal guide will be preferred to get the status of the project.

Students shall be motivated to publish a paper based on the work in Conferences/Technical paper presentations/project competitions/Poster presentations.

Distribution of marks for term work shall be as follows:

a) Weekly Attendance on Project Day
b) Project work contributions as per objectives
c) Hardbound Project Report (Black Book)
d) Term End Presentation (Internal)

The final certification and acceptance of Term Work ensure the satisfactory performance on the above aspects which carries **50** Marks.
Practical & Oral (P&O): (100 Marks)
Practical examination of Major Project-B should be conducted by Internal and External examiners. Students must deliver a presentation and demonstrate the outcomes of their Major Project-B. Oral and Practical will carry **100** Marks

SEMESTER VIII

TEACHING SCHEME

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		Course Category
		TH – P – TUT	Total	TH – P – TUT	Total	
EXC801	Optical Communication Networks	3 – 0 – 0	03	3 – 0 – 0	03	PC
EXC802	Next Generation Networks	3 – 0 – 0	03	3 – 0 – 0	03	PC
EXL801	Optical Communication Networks Laboratory	0 – 2 – 0	02	0 – 1 – 0	01	PC
EXL802	Next Generation Networks Laboratory	0 – 2 – 0	02	0 – 1 – 0	01	PC
INT801	Internship or Project	0 – 24 – 0	24	0 – 12 – 0	12	INT
Total		**6 – 28 – 0**	**34**	**6 – 14 – 0**	**20**	

EXAMINATION SCHEME

Course Code	Course Name	CA Marks			ESE		TW / O / P Marks				Total Marks
		T1	T2	T = T1 + T2	Marks	Duration (in Hrs)	TW	O	P	P&O	
EXC801	Optical Communication Networks	20	20	40	60	2.5	-	-	-	-	100
EXC802	Next Generation Networks	20	20	40	60	2.5	-	-	-	-	100
EXL801	Optical Communication Networks Laboratory	-	-	-	-	-	25	-	-	25	50
EXL802	Next Generation Networks Laboratory	-	-	-	-	-	25	-	-	25	50
INT801	Internship or Project	-	-	-	-	-	200	200	-	-	400
Total		**40**	**40**	**80**	**120**	**-**	**250**	**200**	**-**	**50**	**700**